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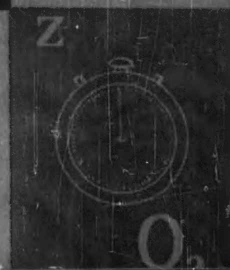

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Energy Cost of Isometric Exercise[1]

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Abstract

The metabolic cost of static exercise was studied in relation to work load. The exercise consisted of the subjects holding 50-, 35-, and 20-lb. weights with the knees partially flexed. Rather sizable oxygen requirements and oxygen debts were obtained, which seemed to increase linearly as the size of the weight increased. When compared with available data on dynamic work of equivalent metabolic cost, the results showed significantly smaller oxygen income and larger oxygen debt for the static exercise. These findings supported the theory that the local circulation was being occluded by the muscle tension during this type of exercise.

SINCE the 1953 reports by Hettinger and Muller (2), considerable interest has been shown in studying isometric (static) exercise as a means of increasing muscular strength. Studies have been made of the intensity and length of time isometric contractions are held; others have contrasted the relative effectiveness of isometric and isotonic (dynamic) forms of exercise in the development of muscular strength (5). The basic research design utilized in these studies has involved a determination of the mean increase in strength as a consequence of varying intensity and frequency of muscular contractions.

None of these studies determined the energy cost of the isometric muscular activity. Textbooks in exercise physiology, even in their latest (1959) editions, fail to give any quantitative or systematic data on the metabolic cost of static exercise, although they give extensive information on the metabolic cost of dynamic work for laboratory types of activity such as treadmill and bicycle ergometer performance, as well as practical activities such as walking, running, and typical daily activities (3, 4). Consequently, there is need to investigate this form of exercise, using systematic variation of muscle load, and testing a group of subjects that is large enough to yield dependable estimates of mean and standard deviation.

In the light of a recent study by Royce (6), there is reason to believe that the blood flow through the muscles is impaired during the maintenance of tension. This implies that much of the energy cost of a contraction, if it is maintained for very long, would have to be paid off in the form of oxygen debt after the muscle has relaxed. In contrast, the periodic compression and relaxation of the muscle pressure against the veins during dynamic work would tend to promote local blood flow toward the heart and thereby increase the oxygen transport during exercise, thus resulting in a comparatively small oxygen debt. The present experiment tested this hypothesis.

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[1] From the Research Laboratories of the Department of Physical Education.

Methodology

Measurements were made with a closed-circuit metabolism apparatus (1) with continuous recording of oxygen consumption during rest, five minutes of isometric exercise, and recovery. All measurements were made in the standing position. The first exercise period consisted of the subject holding a 50-lb. weight against the thighs with the hands. The knees were flexed to approximately 130 deg., so that the major amount of muscular exertion occurred in the quadriceps. The second and third tests, spaced at intervals of one week, were given in the same manner using 35-lb. and 20-lb. weights. In selecting the exercise time of five minutes, primary consideration was given to providing an activity that was sufficiently strenuous to be of interest and yet could be maintained for a length of time so as to permit steady-state measurement of the metabolic energy cost. Longer periods or heavier weights proved too difficult for some subjects.

Twenty-four male undergraduate students, volunteers from physical education activity classes, were used as subjects. They averaged 20.29 years of age ($\sigma = 3.56$), had mean standing heights of 70.05 in. ($\sigma = 3.39$), and weighed 161.14 lbs. ($\sigma = 14.29$).

Results and Discussion

The results of testing under the three experimental conditions appear in Table 1. Rather substantial oxygen requirements and oxygen debts were obtained from this type of exercise. The mean net requirement nearly doubled as the weight was changed from 20 to 50 lbs., going from .155 L/min. to .289 L/min. On the other hand, the mean debt increased from .128 L to .487 L, an increase for the heavy work load of almost four times the light exercise value. Net oxygen income also increased, but only to the extent of about 50 percent.

TABLE 1.—OXYGEN REQUIREMENT FOR STATIC EXERCISE

	Static Exercise Loads					
	20 lbs.		35 lbs.		50 lbs.	
	M	σ	M	σ	M	σ
Net Requirement (*L*/min)	.155	.024	.214	.026	.289	.104
Debt (*L*)	.128	.114	.293	.197	.487	.293
Net Income (*L*/min)	.129	.066	.156	.057	.192	.081
Debt/Income	.992	——	1.878	——	2.536	——

The data of Table 1 show that within the three isometric work loads, the size of the O_2 income, the debt, and the total O_2 requirement all seem to increase linearly in proportion to the size of the weight held by the muscles. The measurement of exercise bouts involving heavier work loads was impractical as explained earlier.

COMPARISON WITH DYNAMIC EXERCISE

In order to avoid difficulty, because static exercise involves no movement, whereas in dynamic exercise movement is present and variable, it was necessary to compare the two types of exercise (static and dynamic) in terms of their metabolic cost. Data are available from a study by Henry and DeMoor (1) for a systematic variation of work intensity in dynamic exercise on a bicycle ergometer. Such work employs much the same muscle groups as those used in the static exercise tests. Table 2 shows results, computed for five minutes of exercise, for a range of oxygen requirements that overlaps the requirements found for static exercise in the present experiment and reported in Table 1. The relationship is graphically presented in Figure I.

TABLE 2.—OXYGEN REQUIREMENT FOR DYNAMIC EXERCISE

	A		B		C	
	M	σ	M	σ	M	σ
Net Requirement (*L*/min)	.219	.033	.338	.046	.638	.122
Debt (*L*)	.166	.060	.356	.114	.681	.215
Net Income (*L*/min)	.186	.032	.267	.053	.502	.103
Debt/Income	.892	----	1.333	----	1.357	----

The metabolic cost of static work resulting from utilizing the 35- and 50-lb. weights overlaps the available values for dynamic exercise. Oxygen debts are approximately 43 percent greater for static exercise in the region of overlap. When compared statistically at .214 L/min. and .289 L/min. metabolic work cost, this difference is significant; the t ratios are 2.76 and 3.36, respectively. Net oxygen income is 19 percent less during static exercise at the same metabolic work levels, which difference is also found to be significant (t ratios = 1.69 and 1.92).[2]

The finding of smaller O_2 income during work, and larger oxygen debt, when static is compared with dynamic exercise at constant metabolic work load, supports the hypothesis that a considerable part of the local circulation is cut off by the muscle tension during the static work. A larger proportion of the oxygen requirement must be met by local oxygen debt in this type of work.

Quite wide differences are present in the ratio debt/income. This ratio is much larger for static exercises, particularly for the higher work loads, since it reflects both the larger debt and the smaller income during exercise.

Summary and Conclusions

The study was designed to investigate the energy cost of isometric exercise. Measurements were made on 24 university students with a closed-circuit metabolism apparatus during rest, five minutes of isometric exercise, and

[2] For 33 degrees of freedom, t ratios of 1.69 and 2.45 denote significance at the .05 and .01 levels, respectively, in the case of the one-tailed test, which is appropriate in the present problem.

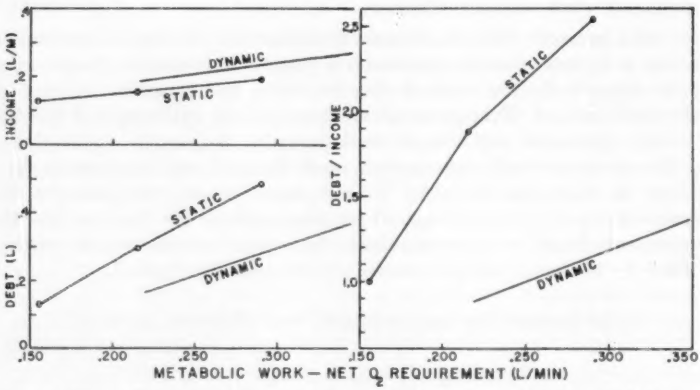

FIGURE I. The relationship of static and dynamic exercise at comparable metabolic work loads.

recovery (all in the standing position). The first exercise period consisted of the subjects holding a 50-lb. weight by the hands with knees partially flexed. Second and third tests at intervals of one week were given in the same manner using 35-lb. and 20-lb. weights. The results indicated that as the weight was made heavier, there was a linear increase in the size of the O_2 income, the O_2 debt, and the total O_2 requirement. There was a significantly smaller O_2 income during work and larger oxygen debt, when static is compared with dynamic exercise at comparable metabolic work loads. The results were consistent with the theory that the circulation was being occluded by the muscle tension, thus requiring that the cost of the work be met by a relatively larger oxygen debt.

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(Submitted 4/20/59)

Effect of Duration of Exercise on Neuromuscular Hand Tremor [1]

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Abstract

This study was an attempt to determine, by controlling certain variables not considered in previous investigations, the relationship between exercise and static neuromuscular hand tremor. Tremor measures of 52 women subjects were taken on three different occasions, the procedure being varied in the amount of exercise prescribed. The results appear to show that tremor increases with duration of exercise.

ALTHOUGH it has been recognized for over half a century, the phenomenon of nonpathological neuromuscular tremor has not been investigated extensively until recently. Preoccupation with tremor as a pathological function and lack of adequate measuring devices have delayed studies of tremor in normal individuals. The introduction of various finely calibrated instruments to the modern research laboratory has made possible fairly accurate measurement of tremor. Beginning with World War II, the need for a high degree of dexterity and steadiness to develop and operate the complicated and highly sensitive instruments of modern science has created an interest in tremor and the role which it plays in skill and efficiency of movement. In addition, the growth of research in physical education and particularly in physiological aspects of movement of the body has led to an interest in tremor as it may influence success in sports activities.

Bucy (2), in distinguishing between various kinds of tremor in normal individuals, defines intention tremor as that which occurs in a part of the body as the result of voluntary contraction. Static tremor, occurring when the part is held still against the force of gravity, is one manifestation of intention tremor. Almost all of the published research on tremor is concerned with the latter type. Edwards (4) and Young (13), in studying the effect of vision on tremor, found that visual cues, or having the eyes open or shut, appeared to make little difference in the finger tremor of normal individuals. Mitchem and Tuttle (9) and Edwards (7) report increase in finger tremor as a result of emotional stress. Mitchem and Tuttle recorded an increase in tremor among a group of dental students just prior to a written examination. Edwards noted greater tremor following recall of anger situations and an even greater increase with the perception of horror pictures. The effect of smoking on finger

[1] This introductory research and a second study in progress were supported by a research fellowship from the Regents of the University of California.

tremor has also been studied by Edwards (5) who reported a significant increase among those smokers who inhaled.

Working under a red light appears to produce a significant increase in finger tremor over that present when working under normal light conditions according to James and Domingos (8). In an investigation involving the effect of mental work on tremor, Sollenberger (11) reported that peripheral tonus is increased under such conditions; this in turn increases the amplitude and decreases the rate of finger tremor. In an experiment designed to determine the effects of rotating the body in a number of positions upon body sway and finger tremor, Edwards (6) discovered significant increases in body sway following rotation, but no significant effect on finger tremor.

Bousfield (1), using a hand ergograph, found that the rate and amplitude of tremor increased as a result of muscular contraction and that this increase varied directly with the degree of fatigue. The same results were noted by Eagles, Halliday, and Redfearn (3) who investigated the effects of sleep deprivation, exercise of the finger, and other exercises making more general demands on the body. Tuttle, Janney, and Wilkerson (12) and Mitchem and Tuttle (9) reported studies purporting to show that tremor increases directly with intensity of exercise. While both of these investigations showed that there was an increase in tremor as the strenuousness of the exercise increased, the design of the experiments was such that all of the testing was completed at one time. Thus, in neither one was the accumulative fatigue brought about by progressively increasing the amount of exercise confronted. Conclusions relative to tremor increase as the result of increase in exercise would thus appear to be somewhat misleading. In an effort to show that the order in which the various amounts of exercise are done has a bearing on tremor measures, Slater-Hammel (10) repeated certain aspects of the investigation by Mitchem and Tuttle but selected a different order of exercise for half the group. Since the results of the two groups were quite different, he concluded that, under this particular experimental design, no statement relative to the effect of intensity of exercise on tremor could be made.

In the present investigation, an attempt was made to control these ambiguities by using an experimental design which avoided the problem of progressive fatigue by utilizing three distinct test periods. In addition, only those differences were considered which were significant at the 5 percent level or above. The present study constituted a pilot investigation of the relationship between exercises of varying duration and static neuromuscular hand tremor rate when the element of accumulative fatigue is eliminated. Further study based on the results herein reported is now under way for the purpose of comparing the tremor rates of skilled and nonskilled performers in response to exercises of varying duration.

Sources of Data

The 52 subjects for this study were all undergraduate women students enrolled in required physical education activity classes at the University of California, Santa Barbara.

The equipment for recording hand tremor consisted of the C. H. Stoelting hand steadiness apparatus and a one-hundredth second electric stop clock set up in circuit with five $1\frac{1}{2}$ volt cells. The hand steadiness apparatus consists of a metal plate containing a series of graduated holes and a metal stylus. The metal plate was mounted on the wall in such a manner that it could be raised or lowered to conform to the varying heights of the subjects. Contact of the stylus tip with the edge of the hole in the metal plate activated the electric clock. When the contact was removed the clock stopped. The measure of tremor was considered to be the total time in which contact was made with the edge of the hole during the measurement period. The hole selected for use was 0.81 in. in diameter.

Because it involves total body movement, the exercise chosen for use in this study was the squat thrust.

Procedure

Each subject was scheduled for testing on three different days approximately one week apart. When the subject arrived for the test she was given a rest period of approximately 10 min. Instructions were read explaining the procedure, and the squat thrust and the use of the apparatus were demontrated. Subjects were then allowed to practice using the tremor apparatus. They stood at right angles to the apparatus and at comfortable arm's reach. The metal plate was raised or lowered so that the arm could be extended at shoulder level. Subjects were instructed to grasp the stylus as they would hold a pencil. After the subject had practiced using the apparatus, a 15-sec. measure of tremor was obtained. This measure was considered to be "resting tremor." The subject then performed the exercise a prescribed number of times to the commands "squat-back-squat-stand," and immediately another 15-sec. measure of tremor was taken. This same procedure (except for demonstration) was followed for each of the three test periods, varied only by the number of squat thrusts required.

Subjects were divided at random into two groups; one performed the squat thrusts in a 3-6-10 order, and the other performed in a 10-6-3 order, the latter chosen at random from the six possible orders.

Results and Discussion

In order to determine whether the two groups differed with respect to resting tremor, the first 15-sec. measures for each subject on each of the three days were totaled and subjected to the t test of the difference between means. The obtained value of 0.137 did not approach significance, and it was concluded that the two groups in this respect seemed to be representative of the same population.

The effect of the order of exercise on resulting tremor measures was determined by comparing the mean performance of the two groups following like amounts of exercise. None of these differences was significant. It was concluded that, since the order of exercise did not affect the resulting tremor,

learning was apparently not a factor. Since this result differed from that obtained by Slater-Hammel (10) and since the main difference in the present study was the time interval between exercise periods, it would seem that the presence of accumulative fatigue had affected the results obtained in that investigation.

Since the two groups did not differ with respect to resting tremor, and since the order of exercise did not appear to affect the results of tremor measures following like amounts of exercise, it was assumed that further statistical analysis could be made of both groups as a whole.

The change in tremor measures (difference between resting tremor and tremor following exercise) for each of the three exercise durations was subjected to analysis of variance (see Table 1). "Between exercise durations" was shown to be significant at the 1 percent level for 2 and 102 degrees of freedom, and it was concluded that the change in tremor measures was not the same for the three exercise durations.

TABLE 1.—MEANS AND VARIANCE ANALYSIS OF CHANGE IN RESTING TREMOR MEASURES FOLLOWING EXERCISES OF VARYING DURATION

Source of Variation	Mean	Sum of Squares	df	Mean Square	F[a]	P
Between Exercise Durations						
Rest - 3SQ	0.4805					
Rest - 6SQ	0.9794					
Rest - 10 SQ	2.0205	64.2104	2	32.1052	36.6409	above 1%
Between Subjects		63.1561	51			
Interaction		82.6167	102	0.8099		
	Total	209.9832	155			

[a] For 2 and 102 degrees of freedom an F of approximately 4.82 is significant at the 1 percent level.

In order to determine which of the three experimental conditions resulted in a significant amount of change, the t test of the difference between means was applied to the three possible combinations of measures. For 102 degrees of freedom, a t of approximately 1.98 is significant at the 5 percent level, and a t of approximately 2.63 is significant at the 1 percent level. The difference between the tremor change following three squat thrusts and that change resulting from six squat thrusts was significant at the 5 percent level, the obtained t being 2.51. The differences resulting from three and ten and from six and ten squat thrusts were both significant at the 1 percent level, the obtained t being 7.21 for the former and 4.70 for the latter. It was concluded, therefore, that these differences could not be attributed to random variation and that increase in duration of exercise resulted in a significant increase in tremor rate.

It must be recognized, however, that the use of the t test in determining differences when more than two items are being compared has some limitations. Results obtained when separate pairs of tests are treated are not necessarily the results which might be obtained on the aggregate. Recent

publications in statistics have described some newer techniques designed more adequately to test relationships. In the present investigation, the fact that no difference was shown between three orders of exercise for the two groups may be somewhat misleading since with a different statistical treatment, "no difference" might not appear in the total.

Conclusions

Within the limits of the foregoing experiment, it was concluded that:

1. Neuromuscular hand tremor following exercises of varying duration does not appear to be affected by the order in which the exercises are performed when the element of accumulative fatigue is eliminated by requiring only one set of exercises in a given experimental period.

2. Increasing the duration of exercise produces a significant increase in static neuromuscular hand tremor rate.

3. While these findings are in general accord with those of Mitchem and Tuttle, they would appear to be based on an experimental design permitting greater validity of interpretation.

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(Submitted 6/15/59)

A Comparison of Fathers and Sons in Physical Ability

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Abstract

Scores achieved by fathers and sons in physical ability tests at Pomona College were studied by comparing the percentage of tests failed by each, determining the difference in the mean scores, and computing correlations between father and son performance in various tests. The findings indicated that a larger percentage of the tests were passed by the fathers, and that their scores were significantly higher in three out of four of the tests. The highest, positive correlations were noted between father and son performance in the broad jump (+.86) and in the 100-yd. run (+.59).

FOLLOWING THE STUDY by Kraus and Hirschland (4) national interest was revived concerning the fitness of contemporary youth in the United States. Although previous studies by Karpovich (3) and other investigators during World War II described the physical inadequacies of young men entering the armed services, longitudinal investigations involving a comparison of the physical abilities of two generations based on the same test battery have not been reported.

The test battery at Pomona College, consisting of chins, running broad jump, standing fence vault, and 100-yd. run, was established in 1925 in order to discover the physical shortcomings of men entering the program. Those failing to meet arbitrarily set standards in each of the tests failed the battery and were placed in special classes.

Previous investigations by Nixon (8), Merritt (7), and Ilsley (2) dealing with this testing program generally failed to discover any correlations of predictive value between the ability scores and athletic success, academic achievement, health, and other factors. A study completed in 1955 indicated a general decline over the years in ability to perform the chin-up and in the total standard scores based on annual means. During that investigation it was noted that there might be a number of father and son scores available for comparison when the class of 1962 was tested in September of 1958. An intergeneration comparison of the scores was planned.

This present study was designed for the purpose of comparing scores achieved in physical ability tests at Pomona College by fathers and by their sons from 1925 to 1959.

Procedures

The Alumni Office of the College supplied data concerning father-son combinations enrolled during the time the tests were administered. Of the 39 combinations who had been enrolled, the Physical Education Department had

records for 24 pairs. The other scores were missing, or the individual had been excused from taking the battery for medical reasons.

The passing scores were established arbitrarily by members of the Physical Education Department in 1925 and have remained the same during the years. These standards are: chin-ups, 6 or more; 100-yd. run, under 13 sec.; fence vault, nipple high; broad jump, over 15 ft. The 100-yd. run was timed to the nearest .10 sec., with a gun start. The broad jump was measured from the point the boy left the ground, with three trials allowed to obtain the best score. Partial chin-ups were not counted, and trials were allowed for the fence vault. In all the tests the boys were encouraged to do their best.

Although specific reliability checks were not made at Pomona College, the tests were under the supervision of the same two men during the entire span of their administration.[1] The reliability measures of all the tests in the battery are considered to be high (over +.90) according to common findings presented by Larson and Yocom (5).

Comparisons were made between the percentage of fathers and sons failing the total battery and failing the individual tests. In addition, the percentage of tests failed by both fathers and sons was compared with the percentage of tests failed by the 4000 men tested through the years.

The next step was to compare the mean scores achieved by fathers and sons. The Fisher t test for the significance of difference between means of small samples was utilized to make this comparison.

Correlations were computed between the father and son scores in the individual tests, and in the total score, to ascertain familial similarities in the performance of the tests.

Findings

Comparisons of the fathers' and sons' abilities to pass the individual tests and the total battery indicated superior performance on the part of the fathers (Table 1). This superiority was amplified when the mean scores were compared. The difference in the means between father and son performance in the chin-ups, 100-yd. run, and fence vault exceeded the 5 percent level of confidence, indicating a real and significant difference in the scores.

The relatively high, positive correlation between father and son performance in the broad jump (+.86), indicated a familial similarity in the ability to perform this test item. A moderately high, positive correlation in the 100-yd. run of +.59 indicated this familial similarity to a less degree. The other correlations, while positive, could not be considered to have any predictive value.

Conclusions

1. The physical ability of the fathers was superior to the ability exhibited by the sons, based on the percentage of tests failed by each group.

2. The performance of the fathers was significantly better in the chin-ups, 100-yd. run, and standing fence vault, based on comparison of mean scores.

[1]Robert L. Strehle and Colvin Heath did the testing.

3. There was a positive correlation between father and son performance in the broad jump of .865, and a moderately high, positive correlation in the 100-yd. run of .595, when the fathers' performance was correlated to that of their sons.

TABLE 1.—NUMBER AND PERCENTAGE OF FAILURES

Item	Group	Failures Number	Failures Percent	Percent Failures of 4000 Men Tested
Broad Jump	Father	2	8.3%	27%
	Son	5	20.8%	
Chins	Father	3	12.5%	14%
	Son	6	25%	
Fence-vault	Father	2	8.3%	10.4%
	Son	5	20.8%	
100-yd. run	Father	1	4.2%	18.2%
	Son	6	25%	
Total Items in Battery Failed	Father	8	8.3%	No data available
	Son	22	22.9%	
Failing the Battery	Father	4	16.7%	36.3%
	Son	10	41.7%	

TABLE 2.—COMPARISON OF THE MEAN SCORES

	Broad Jump	Chins	Fence-vault	100-yd. run	Total Score (Standard Score)
Mean Score of 4,000 Men tested	15′ 2″	7.6	4′ 8″	12.5 secs	200.8
Fathers' Mean Score	15′ 5″	7.6	4′ 11″	12.6 secs	216.7
Sons' Mean Score	15′ 6″	4.7	4′ 6″	12.8 secs	188.9
M diff.	1″	2.9	5″	.2 secs	25.8
S. E. of M diff.	1.26	1.11	1.92	.0750	----
t ratio	.783	2.636[a]	2.590[a]	2.66[a]	----
Father-son *r*	+.865	+.375	+.038	+.595	+.329

[a] Significant at the 5 percent level of confidence.

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The Establishment of Principles of Human Relations That May Be Used in the Integration of All-White or All-Negro Camps to Interracial Camps[1]

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Abstract

The problem of this study was to derive and validate principles of human relations that may be used in the change from all-white or all-Negro camps to interracial camps and to determine the workability of each principle by applying it to a selected group of five interracial camps. Data for the study were obtained from the literature related to human relations and camping. Statements from the literature were formulated into principles. Each principle was validated by documentary analysis and by a jury of experts.

IN KEEPING WITH American philosophy, more camps each year are becoming interracial. There is no place for discrimination of any type in camping. Camp directors are keenly sensitive of these trends and are greatly interested in getting help to meet the situation.

Jefferson (8) stated that changing from the accustomed to new ways of behaving created its own problems. She added that all of us recognize the tendency of people to resist anything new, particularly if it is radically different from the old. Camping will not have fully achieved its educational possibilities until the philosophies of good human relations are followed to the fullest degree.

Review of Literature

At the time of this study there has been little written on the transition of camps from the all-white or all-Negro to interracial situation. Backus, Boorman, and Dimock (1) have made a study of camps as character education agents. They state that organized steps are needed in planning leadership, in selecting campers, in programing, in group practices, and in public relations. Schellberg's study (12) on the evaluation of the camping program for Camp Fire Girls indicates the need for girls to have a wholesome feeling toward others. Dodson (2) has made a very significant study on integration

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[1] This investigation was conducted under the direction of Dr. Raymond A. Weiss, New York University, in partial fulfillment of the requirements for the degree of Doctor of Education, 1958.

in which he reveals a number of principles that should be adopted in interracial settings. Lewis (10), Grayson (5), Kramer (9), Taba (13), Yauch (14), and Frazier (4) have published material on integration and on the importance of reinterpreting our American democracy.

Procedures

The procedures in collecting data for this study involved the following separate steps: (1) a study and analysis of the concepts of human relations in a democracy, (2) the development of a set of principles of human relations that may be used in the integration of ethnic groups, (3) a study and analysis of the characteristics of camping to determine the desirable characteristics of camping that may aid in improving human relations, (4) the development of principles of human relations that may be used in the transition of all-white or all-Negro camps to interracial camps, and (5) testing the workability of the principles thus established as applied to a selected group of camps.

Concepts of Human Relations in a Democracy

The purpose of this phase of the investigation was to develop a philosophical basic of democratic human relations for the entire study. It was assumed that the troubles of the world today can be solved only by people who have a clear understanding of what democratic human relations are and who possess skills to develop such relations. It was the function of this phase of the study to examine the broad concepts of human relations in the United States, in an effort to understand the elements or factors which prescribe the kinds of relationships that need to be developed.

In deriving the concepts of human relations, five fundamental steps were involved.

1. *Identifying the Literature.* The purpose of this step was to compile a list of references from which to collect materials about human relations. The literature in the areas of human relations, sociology, government, psychology, education, history, and religion was reviewed for its relationship to this study.

2. *Collecting Statements.* The above materials were analyzed for statements regarding human relations that might be useful for this study. When a proposed concept of human relations, or a definite statement about human relations, or an inference regarding human relations was found, the statement was transferred to a card.

3. *Organizing the Statements.* These statements were organized into three headings on the basis of their content. A preliminary study of the literature indicated that the most pertinent and appropriate categories of human relations were as follows: (a) Social Justice; (b) Freedom; and (c) Civil Rights.

4. *Formulating Concepts.* The statements were formulated into concepts, accompanied by the documentary analysis to support the validity of each. When a statement was found that could not be supported by at least five

authorities, it was not used. From the available literature the investigator formulated 34 concepts.

5. *Validating Concepts.* The 34 concepts were submitted to six experts in human relations in university programs. These consultants served two main purposes: (a) to review the 34 concepts for their usefulness, validity, and need for revision and (b) to give their approval of the concepts finally formulated.

In regard to the first purpose, the consultants indicated there were too many items in certain areas and made suggestions for reducing their length. There was some overlapping of activities, and the consultants believed combining certain concepts and deleting others would be feasible. The consensus of the group was that all the concepts were important and valid to the study. By the elimination of irrelevant statements and repetitions the original number of concepts was reduced to 14. The consultants were then asked to give their approval of the 14 final concepts.

The criteria for the selection of the six consultants were their qualifications in the area of human relations. Only recognized authorities in the field of human relations were selected under the following criteria:

1. He has published a book or articles on human relations.
2. He has taught human relations in a college or university.
3. He is active in the profession of human relations and provides leadership at professional meetings.

Principles of Human Relations That May Be Used in the Integration of Ethnic Groups

It was the purpose of this phase of the investigation to develop principles of human relations that may be used in the integration of any ethnic group. Five specific steps were used in deriving these principles. These steps follow the same general plan used in the previous phase of this study.

The statements were organized into the following four headings on the basis of their content:

1. Human relations material relating to democratic values of society
2. Human relations material relating to individuals
3. Human relations material relating to leadership
4. Human relations material relating to minorities.

Characteristics of Camping That May Aid in Developing Human Relations

It was the purpose of this phase of the investigation to study the aims, objectives, and characteristics of camping and to formulate the characteristics into statements.

In formulating the characteristics of camping, five fundamental steps similar to the method used in the first and second phases of this study were involved. The statements developed were organized into the following appropriate areas:

1. Cabin life
2. Sports program
3. Isolation
4. Dramatics, dancing, music, arts, and crafts
5. Concentrated time
6. Coeducational life
7. Spiritual program.

Data supporting these characteristics were obtained from Manley and Drury (1), Drought (3), Irwin (7), and Hammett and Musselman (6).

Principles of Human Relations That May Be Used in the Transition from All-White or All-Negro Camps to Interracial Camps

The purpose of this fourth phase of the study was to formulate principles for interracial camping. In order to solve this problem, two major sources were used. The primary source was the literature found in phases one, two, and three. The second source was camping and human relations literature.

The material presented in phase one furnished the investigator with an understanding of the broad concepts of human relations in the United States. With this as a guide, the investigator was able to develop principles of human relations that could be used in the integration of ethnic groups (phase two). Principles were developed from as many of the concepts as possible. The next step was to study the characteristics of camping to ascertain if such characteristics could contribute to improving human relations (phase three).

The material from phases one, two, and three has aided in the development of principles for the fourth phase of the study. The information in the previous phases was validated, and much of the material was rearranged to apply to interracial camping.

In deriving these principles of human relations, five fundamental steps were involved. These steps follow the same general plan used in the previous phases of this study. Step one (identifying the literature) involved two procedures: (1) identifying the literature found in phases one, two, and three, and (2) identifying all other camping and related literature available.

The statements were organized into seven headings on the basis of their content. A preliminary study of the literature indicated that the most pertinent and appropriate categories for interracial camping were as follows:

1. Camping material relating to philosophy
2. Camping material relating to objectives
3. Camping material relating to administration and organization;
4. Camping material relating to program
5. Camping material relating to leadership
6. Camping material relating to selection of campers counselors
7. Camping material relating to public relations.

The statements were extracted and formulated into 23 principles of human relations that could be used in the transition of all-white or all-Negro camps to interracial camps.

The next step in the procedure was to make use of a group of five authorities in interracial camping or in interracial institutions. This jury was in-

structured to indicate approval or disapproval of each principle. If a member of the jury disapproved of a principle, he or she was requested to state reasons. If, in the opinion of the investigator, the comments were feasible and worth while, they were used to improve or discard the principle.

On the basis of the comments and suggestions of the jury members, each of the 23 principles was then edited so that it expressed in a concise and unambiguous way the essential idea involved. Finally all of the members of the jury approved of the 23 principles as being valid and worth while for this investigation.

The criteria for the selection of each authority were the individual's qualifications in the area of interracial camping or interracial institutions related to the problem. The authority met at least one of the following standards:

1. Experience of at least eight years in camping as a director or supervisor, at least two years of the eight in interracial camping.
2. Present or past position of responsibility in an interracial institution related to the problem, such as social agency, community center, school, or church.

Workability of the Principles Established in the Previous Phase Applied to Five Interracial Camps

The fifth phase of the study was to determine the workability of the application of the 23 principles of human relations for interracial camping. The usefulness of the principles was validated through the use of five interracial camps. The principles were submitted to the camp directors with instruction to rate them on a scale which indicated the extent of usefulness to the total camp program. The directors rated each principle as applying "all or almost all times," "part of the time," or "rarely or never." There was unanimous agreement that all 23 were useful in organizing and developing interracial camping.

Five camps were selected because the investigator felt that a satisfactory cross section of interracial camps could be attained with this number. Each camp met the following criteria:

1. The camp met the criteria found in the delimitations of this study.
2. The camp is a member of the American Camping Association or the Association of Private Camps.
3. The camp directors agreed to cooperate fully.
4. The investigator is familiar with the camp.
5. The camp program and administration are similar to those of any camp of equal size and nature, that is, each camp offers a well-balanced program including sports, crafts, dramatics, and religious activities.

Results

The principles of human relations that may be used in the integration of all-white or all-Negro camps to interracial camps and their groupings, as established in this study, are as follows.

GROUP I. PRINCIPLES OF HUMAN RELATIONS IN INTERRACIAL CAMPING

1. The interracial camp should have a vital concern for the social, phychological, and emotional growth of all the individuals in camp.
2. The members of an interracial camp should believe in the philosophy of democratic group participation.
3. The interracial camp should take great care that its mottos, slogans, and traditions are not embarrassing to any race or religion.
4. The library of an interracial camp should contain material which can serve to give campers the history and therefore a better understanding of the races and their various problems.

GROUP II. PRINCIPLES OF HUMAN RELATIONS IN INTERRACIAL CAMPING RELATED TO OBJECTIVES

5. The objectives should be the result of committee deliberation and should be clearly stated for all individuals concerned.
6. The objectives should serve as guides to provide opportunities for the development of the characteristics of camping that will aid in the development of human relations.
7. The objectives should concur and be harmonious with the concepts of human relations in a democracy.

GROUP III. PRINCIPLES OF HUMAN RELATIONS IN INTERRACIAL CAMPING RELATED TO ORGANIZATION AND ADMINISTRATION

8. The camp director will need to exercise positive leadership in the development of human relations values.
9. The camp director will need to make it clear to his counselors, staff, and campers, as well as the parents, that he intends to take positive steps to improve interracial relations.
10. The campers should be grouped as nearly as possible according to their interests, abilities, and choices.

GROUP IV. PRINCIPLES OF HUMAN RELATIONS IN INTERRACIAL CAMPING RELATED TO LEADERSHIP

11. The cabin counselor should possess qualities of a good leader, such as friendliness, excellent character, co-operativeness, tolerance, pleasing personality, cheerfulness, and fondness for working with children, as well as an understanding and appreciation of race relations.
12. The administration should employ an integrated staff.

GROUP V. PRINCIPLES OF HUMAN RELATIONS RELATED TO THE SELECTION OF CAMPERS AND COUNSELORS FOR INTERRACIAL CAMPS

13. Counselors should be selected who have had experience and background in democratic living.
14. The camp staff should know as much as possible concerning the social and economic backgrounds of the campers and their parents, as well as their previous interracial experiences.

GROUP VI. PRINCIPLES OF HUMAN RELATIONS RELATED TO THE PROGRAM OF INTERRACIAL CAMPS

15. The camp program should be arranged to attain the camp objectives.

16. The camp program should provide experiences for a widening circle of friendships and an appreciation of fellow campers of different racial groups.

17. Through the camp program the camper should be made conscious of the effect of his conduct on the group.

18. The camp program should encourage the camper to "belong" and participate in the plan-making of a democratic group.

19. The camp program should encourage service to others by helping the camper accept and carry out his share of responsibility in improving race relations.

20. The spirit of brotherhood should prevail throughout the camp program.

GROUP VII. PRINCIPLES OF HUMAN RELATIONS IN INTERRACIAL CAMPING RELATED TO PUBLIC RELATIONS

21. The community leaders should be well-informed about the camp's integration policies and procedures.

22. An effective public relations program, involving all of the camp personnel, should be maintained throughout the year.

23. External influences should not be allowed to interfere with the integrated program.

Recommendations

The findings of this research appear to justify the following recommendations.

1. According to the evidence revealed, the camp has many desirable characteristics that may aid in the development of human relations.
2. Camps should not discriminate on the basis of race, color, religion, creed, or national origin in their admission practices.
3. All camps should publish complete and precise statements of their admission policies. These policies should clearly indicate that admission to the camp is open to all and that the camp adheres to a policy of non-discrimination in any form.
4. Quotas limiting the number of applicants to be admitted on the basis of race, religion, or national origin should not be allowed.
5. Only those admission questions on application blanks are valid which help to determine the camper's value as a camper.
6. The camp committee should see that the 23 principles of human relations for interracial camping established in the study be followed to the extent possible.

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Relationships between Individual Differences in Strength, Speed, and Mass in an Arm Movement[1]

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Abstract

According to physics, the equation $F = 2\,md/t^2$ determines the force F required to move a mass m through a distance d in t seconds. Two experiments were performed on college men ($n = 35$ and 30) in which a lateral arm movement of approximately 90 deg. involving about 4 ft. of hand travel, was made at maximum speed. The movement time t, the effective arm mass m, and the static dynamometer strength s of the muscles were measured for each subject. The reliability of individual differences in all measures was above .96. There was no significant correlation between static strength and "strength in action" computed from arm mass and speed of movement. The results agree with the concept that strength as ordinarily measured is determined by a neuromotor coordination pattern rather than the ultimate physiological capacity of the muscle. The neuromotor pattern energizing the muscle is different during movement. Absence of correlation is another example of the high specificity of neuromotor coordination skills. Reaction times were also measured and found to be uncorrelated with speed of movement.

SEVERAL STUDIES DURING the past few years have presented data which reveal the extremely specific nature of large muscle neuromotor coordination abilities (1, 2, 6, 10). These facts suggest the possibility of high specificity in the ability to exert force with a particular muscle group in different tasks. There may indeed be little or no relation between strength in action, for example, as measured by an individual's ability to accelerate the mass of a limb and move it with high velocity, and the strength of the involved muscles as measured statically with a dynamometer during a strength test. Such an absence of relationship would require considerable revision of current ideas concerning the structure of motor abilities.

The hypothesis proposed is that the muscular force which is exerted in a movement made at maximum speed is determined by a neuromotor coordina-

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[1]From the Research Laboratory of the Department of Physical Education at Berkeley. The study designated Experiment 1 was supported by a grant from the Faculty Research Fund.

tion. The ultimate limit of this force is the true physiological capacity of the muscle; the amount of this potential strength that is exerted in a movement of maximal speed is determined by neural function in the coordination and integration centers of the nervous system rather than by the muscle. Even a maximal static contraction voluntarily initiated is visualized as a neuromotor coordination, capable of being influenced by motivation and a variety of other factors. The neuromotor integration pattern of such a static contraction might be expected to be different from the more complicated pattern for maximal contraction during movement. Considering the known specificity of other neuromotor coordinations mentioned earlier, the hypothesis predicts that there will be very little correlation between individual differences in static or dynamometric muscular strength and strength in action during a movement.

Theoretical Considerations

Assuming linear acceleration, the force F required to move a mass m some specified distance d in the time t is given by the expression

$$F = 2md/t^2$$

where force is in dynes, mass is in grams, distance is in centimeters, and time is in seconds. The problem, therefore, is to measure the effective mass of a limb, such as the arm, and determine the time required to move that limb a specified distance at maximal speed (excluding reaction time). Individual magnitudes of F computed by the formula are then to be correlated with individual differences in muscular strength s exerted statically against a dynamometer when the arm is in the position involved in the movement.

There are, of course, certain complications. There has been little study of basic movement, and it cannot be said with certainty whether the acceleration involved in some specified arm movement is linear or ballistic. Limitations imposed by this lack of knowledge will be considered later.

It is necessary to avoid confusion between effective mass as required in the formula and some estimate of total arm mass or weight. We are not dealing here with the mass of a detached arm, but rather with the effective mass of the arm measured at some specified distance L from the shoulder joint. The functional rigid arm is a lever, supported and fixed at one end by a pivot. Regardless of its shape, its mass can be visualized as concentrated at the measurement point L and measurable as the relaxed apparent weight of the free end of the arm at L. Similarly, we are not concerned with the force applied by the muscle to its insertion or attachment. The physics of the situation is concerned with the effective strength s (or computed force F) as exhibited at L. It follows that the movement distance d must be determined as the path of the measurement point L during the arm movement.

The correlation of major interest is that between so-called true scores in F and s. This requires a determination of the reliability of individual differences in the measured variables, in order to correct the fallible scores for attenuation if that should prove necessary. Other requirements are that

effective mass must be directly measured, and that the movement must be free and unterminated for some distance beyond the last timing station, so that there will be no involvement of opposing muscles during the pull-up at the end of the arm swing. It may be noted that while the only previous study relating the measured strength of a limb and its speed of movement does not meet these requirements, the results indicate that there is no correlation between strength and speed (9).

Apparatus and Method

Measurement of Speed of Movement. The subject stood erect with his back to a wall. The hand of his laterally extended right arm rested on a microswitch. Keeping his elbow and wrist rigid, he swung his arm leftward past the medial plane of the body, moving as fast as possible, to strike the target with maximal force.

In the first experiment, a vertical string was positioned at arm length directly in front of the subject's shoulder, the target being a free-hanging towel placed 17 cm. laterally beyond the string. Contact of the hand with the string pulled out a contact in a second microswitch and pulled the string loose. A chronoscope having a variable error of 0.0013 sec. and a constant error of 0.0062 sec. was automatically started when the subject's hand left the first microswitch and was stopped when the hand swept through the string. The circuitry and method of calibration have been given elsewhere (4).

The angular rotation of the arm about the shoulder pivot in this first experiment was 90 deg. for the average subject; the distance moved, 100.1 cm., was the same for all individuals. After a suitable number of practice swings for warm-up, each subject was given 20 trials, each preceded by a preliminary verbal signal and then a light flash as the starting signal. Care was taken to ensure that the body was not twisted during the movement, at least up to the target point.

In the second experiment, the target string was positioned exactly in the median plane. Consequently, there was some variation in the distance moved ($\sigma = 3.34$ cm.) as a result of differences in arm length and shoulder width. The average distance moved was 125.3 cm.; the angular movement was approximately constant at 109 deg. Each subject made 40 trials. A reaction time chronoscope started by the stimulus light switch was stopped automatically when the subject removed his hand from the first microswitch at the beginning of movement. This was a double action microswitch; removal of the hand also started the movement time chronoscope, which was stopped by touching a string as in their first experiment.

The time scores and distances were used to compute the average velocity for each subject, and this was converted back to a corrected time score for the standard distance (125.3 cm.). These scores were used for the correlations. Computations of scores in F, using Formula 1, used the direct data on time and distance for each subject.

Measurement of Arm Mass. In both experiments, the effective arm mass was measured while the subject reclined on his back on a table. His right arm was supported by a thin plywood board about 7 cm. wide that was hinged to the edge of the table directly under the center of the shoulder joint. A sensitive spring scale having a range of 2.2 kg. (read to 0.02 kg.) was supported by a stand, arranged so that a cord loop attached to the scale could be placed to support the hinged board exactly at the measurement point L (the head of the index finger metacarpal). Calibrated marks on the board permitted observation of the arm length at the same time. The effective weight of the board was subtracted from the observed mass. Ten measurements were taken.

Measurement of Strength. A spring scale having a range of 16.3 kg. (read to 0.1 kg.) was used. It had been modified by the addition of a friction slider to indicate the maximum force obtained in each trial. Twenty percent of the subjects had to be tested with a larger spring scale of 65 kg. capacity (read to 0.2 kg.). The bottom of the scale was adjustably attached to a floor hook; the movable part of the instrument was connected to a fabric loop held in the subject's hand at the measurement point L. Three trials were given—one each at the beginning and end of the arm mass measurement, and a third at the midpoint. This allowed for a reasonable amount of rest between trials. The mean drop-off was 1.0 percent from the first to second trial in Experiment 1 and 2.6 percent in Experiment 2, compared with 0.7 and 0.8 percent drop-off from the second to third trial. None of these changes are significant, since the largest t-ratio computed from the differences is only 1.57. All spring scales were calibrated with standard weights. The effective weight of the arm was, of course, added to the scale reading of each subject, since he was pulling against gravity as well as against the spring during the measurement.

Subjects. In the first experiment, there were 35 subjects, heterogeneous as to age (M $= 29.7$ yrs., $\sigma = 9.46$). The average height was 70.1 in. ($\sigma = 2.64$); the average weight was 167.2 lbs. ($\sigma = 19.5$). All were men, physically active in their habits since they were physical education instructors or major students (graduate or undergraduate).

The second experiment used 30 male students who were volunteers from activity classes. They were younger than the first sample and rather homogenous in age ($M = 19.7$ years, $\sigma = 3.77$). Their height ($M = 71.3$ in., $\sigma = 2.81$) was about the same as found in the first sample ($t = 1.68$), but they were significantly different in other respects. They were 5.6 percent heavier ($M = 176.6$ lbs., $\sigma = 17.6$, $t = 2.01$). As will be shown in a later table, their arms were 2.9 percent longer ($t = 2.2$), had 8.8 percent greater mass ($t = 2.59$), and exerted 8.4 percent greater static force ($t = 2.50$). There is good reason, therefore, to consider the two groups of subjects as samples of two populations that differ in these basic factors. If similar correlation patterns should be found in both experiments, a wider degree of generalization would therefore be possible.

Experimental Results

Reliability of Individual Differences. The test-retest reliability coefficients, computed as the correlations between the first half and second half of the measurements, are all above $r = .90$. They are shown in the upper part of Tables 1 and 2. In the case of strength, the tabled coefficient is the z-transformation average of the three correlations obtained between single measurements. All such single correlations were .92 or higher in both experiments. The full-test reliabilities, computed from the raw reliability coefficients by the Spearman-Brown method, are given in the diagonals of the tables.

Intercorrelations. The pattern of intercorrelations is very similar in the two experiments, as may be verified by comparing the data of Table 1 with those in Table 2. Interest is, of course, centered in the correlation between measured strength s and "strength in action" F computed from time, distance, and mass by use of Formula 1. This correlation is very low in both experi-

TABLE 1.—DESCRIPTIVE STATISTICS AND CORRELATIONS FOR EXPERIMENT 1
(Tabled figures below the first two lines are correlation coefficients. Italicized coefficients on the diagonal are Spearman-Brown corrected reliabilities.)

		s (kg)	F (kg)	s/m	t (sec.)	m (kg)	L (cm)
Mean		15.53	9.06	14.27	.1606	1.107	63.78
S. D.		2.22	2.19	2.57	.0161	.136	3.38
Reliability	(r)	.9297	.9309	.9386	.9156	.9626	.9872
Strength	(s)	*.9751*	.1723[a]	.6777	.0616[a]	.2519[a]	—.0598[a]
Est. force	(F)		*.9642*	—.2967[a]	—.8641	.5922	.2103[a]
Force/mass	(s/m)			*.9683*	—.0378[a]	—.5055	—.3950
Time (90°)	(t)				*.9559*	—.1347	.0293
Arm mass	(m)					*.9809*	.4808
Arm length	(L)						*.9936*

[a]The designated coefficients fail to have statistical significance at the 5 percent level.

TABLE 2.—DESCRIPTIVE STATISTICS AND CORRELATIONS FOR EXPERIMENT 2
(Tabled figures below the first two lines are correlation coefficients. Italicized coefficients on the diagonal are Spearman-Brown corrected reliabilities.)

		s (kg)	F (kg)	s/m	t (sec.)	m (kg)	L (cm)
Mean		16.83	6.12	14.16	.2242	1.204	65.63
S. D.		2.46	3.41	2.15	.0315	0.158	3.26
Reliability	(r)	.9246	.9275	.9298	.9206	.9453	.9359
Strength	(s)	*.9746*	.2084[a]	.7550	—.1892[a]	.1380[a]	.0190[a]
Est. force	(F)		*.9624*	—.1001[a]	—.9013	.3805	.3207[a]
Force/mass	(s/m)			*.9636*	—.1530[a]	—.5636	—.2071[a]
Time (125°)	(t)				*.9587*	—.1268[a]	.0382[a]
Arm mass	(m)					*.9719*	.4443
Arm length	(L)						*.9669*

[a]The designated coefficients fail to have statistical significance at the 5 percent level.

ments. When fully corrected for attenuation in both variables, the figures are .178 and .215. Neither is significantly different from zero. Even if the two experiments were combined to secure a larger number of degrees of freedom, this correlation would not be statistically significant.

The data have also been used to compute the force/mass ratio, since the acceleration of the arm from rest to maximum speed, and therefore the average speed during the movement (or the reciprocal of the time required for the movement), must necessarily be inversely proportional to the mass that is being accelerated. This would hold true even if acceleration was not linear. Here, the correlation of interest is that between the ratio s/m and the time required for the movement. When fully corrected for attenuation in both variables, this correlation is —.039 in Experiment 1 and —.160 in Experiment 2. Neither is statistically different from zero, and both are very low.

Another approach that avoids the assumption of any particular form of the acceleration curve is the computation of the partial correlation between movement time and observed strength, holding statistically constant the influence of individual differences in effective arm mass. (This is the correlation that would have been found if all subjects had the same arm mass). In Experiment 1, the partial correlation is .099; in Experiment 2 it is —.175. The results, therefore, are not appreciably different from those obtained with the force/mass ratio.

It may be seen that there is a fairly high correlation between computed force F and observed time t. This is a meaningless relationship. Formula 1 shows that the variables used to compute F consist of m and the reciprocal of t, the latter being squared and therefore making a strong contribution to individual differences in the estimated force. Consideration of the correlations between the measured strength s and the variables m and t reveals that they are so low as to be statistically nonsignificant.

Confirmation of Strength Measures. Because criticism might be directed toward possible imperfections in the method of measuring arm strength, 18 of the subjects were retested about two months later, using a standing rather than reclining position. A horizontal arm board hinged to a supporting stand was adjusted so that the pin of the hinge was even with and slightly below the center of movement of the shoulder joint. The stand was equipped with a backboard and foot rests so that the subject could brace himself firmly by hooking his free arm about the backboard. His right arm pressed against the horizontal hinged board at the elbow and hand. The dynamometer was attached to the board.

The arm strength of the subjects was measured with this device and also retested by the original method. The correlation between the two is .918, which clearly shows that individual differences in strength are substantially the same in the two methods. It is found that the average strength is 12 percent higher using the original method ($t = 5.59$, which is statistically

significant). It seems likely that the subject is more firmly braced, and thus in a more favorable position to exert his maximal strength, when the original method is used. There is no significant difference in the test and retest measures using the original method ($t = 1.68$). The correlation between test and retest is .882.

Computed Strength in Action. Using the data of Table 1 for mean mass and time, and 101.1 cm. as the distance moved, calculation of the dynamic force by means of Formula 1 yields 8,891,700 dynes for Experiment 1. When this is divided by 981,000 (the conversion factor to change dynes to kg.), the action strength is 8.85 kg., to be compared with 15.5 kg. for measured static strength. In Experiment 2, where the average distance moved was 125.3 cm., the figure is 6,002,500 dynes, which is equivalent to an action strength of 6.12 kg. This is to be compared with 16.8 kg. for static strength.

Correlation between Reaction and Movement Times. A result of secondary interest is the correlation between *RT* and *MT*, using the measurements available in Experiment 2. (*RT* was not measured in Experiment 1.) The observed correlation is $r = .0572$, which becomes .0594 when fully corrected for attenuation in both variables. The mean *RT* is .1935 sec. ($\sigma = .0247$). Absence of a correlation between these two variables is a typical finding that has been observed in numerous other studies from this laboratory, although occasionally a low but statistically significant positive or negative correlation has been reported (3, 7, 11). Pierson has recently revived interest in the *RT-MT* relationship (8).

Discussion

The calculations of dynamic force yield values considerably smaller than the observed strength in both experiments. Since the formula assumes that acceleration is linear and therefore present throughout the movement, it seems likely that the main part of the discrepancy can be explained by postulating that acceleration decreases during the movement; it may even be ballistic. The observed static strength (16.2 kg.) acting on the observed mass would produce an acceleration of 13,700 cm/sec^2, and it would require only the impossibly short time of .12 sec. to move 100 cm. If, however, it be assumed that the full force of 16.2 kg. is exerted only at the beginning of the movement, with an exponential decline in effective force during continuation of the movement, one can visualize an acceleration curve that is consistent with the observed average movement time and average static strength. The formulae that describes the acceleration and velocity curves of sprint running may be used (5), employing a rate constant k of 30 sec.$^{-1}$ and a maximum velocity v_m of about 800 cm/sec. It would be assumed that full force could be applied for approximately two hundredths of a second before the decline set in.

This hypothetical explanation of the velocity curve of the arm movement would postulate that the initial force exerted would be the same as the static

strength. Because of individual differences in the neuromotor coordination pattern, there would be differences among subjects in the length of time that this maximal force would be applied to the mass being moved. There would also be differences among subjects in the rate of decline in applied force during the movement. Thus the maximal force of individuals might conceivably be their static strength, and yet there could be an absence of appreciable correlation between strength and movement time. Further research will be necessary to test this hypothesis.

There must be some reasonable explanation of the low or zero correlation between strength and speed of movement. The hypothesis presented in the introduction is rather general and needs development, either along the lines suggested above, or in some other direction.

It should be emphasized that the correlational approach used in the present study was not concerned with the absolute magnitude of the muscle forces. The question was whether individuals whose static strength scores indicated relatively strong muscles (or muscles that were strong in relation to the effective mass of the object they moved) were also individuals who tended to have relatively great speed of arm movement. Both experiments agreed in showing that this correlation was approximately zero.

This finding is not necessarily to be interpreted as proving that there is no correlation between speed and strength. Factor analysts have used these terms in a way entirely different from the way they are used in the present study. However, the present writers do question whether there are any such abilities as "pure speed" and "pure strength." Pure tests of such abilities have never been discovered, and one wonders what their mechanism could be. Physically, an object being moved resists acceleration in proportion to its mass; the speed of its movement must necessarily be a result of some force that is applied to it, and the muscles are the machines that supply that force. The immediate question at issue is whether the speed that results from the effective muscular force that is mobilized for a standardized movement (or individual differences in the amount of that force) can be measured by a static dynamometer test of those muscles. Evidently the answer to this question is no, at least for the conditions of the present experiments. This answer is consistent with other observed facts, namely the extremely low correlations that are found between various types of large muscle coordination abilities. It is consistent with the hypothesis that strength in action is controlled by the neuromotor coordination centers of the nervous system and hence should exhibit the same high degree of specificity that is found in other types of neuromotor performances.

This position does not necessarily exclude the possibility that strengthening the muscles involved in a movement will make it possible for the individual concerned to make a faster movement. It does imply that if the strength is gained through exercising with some other movement than the one under consideration, full advantage of the greater strength potential of the muscle would require practice with the specific movement so that the

specific neuromotor coordination can take advantage of the greater strength. It may be noted that an experiment to test this concept would require more rigid control than is ordinarily practical in strength development studies.

Further research will no doubt uncover situations in which appreciable correlations can be demonstrated between measured strength and speed of movement, since speed of movement is necessarily caused by muscle force. It is difficult to accept the extreme specificity found in the present experiment as applying to all movements and all strength measurements. The nature of the situations required to produce such correlations is not clear at the present time.

Summary and Conclusions

The time required to make a horizontal straight-arm adductive swing of approximately 90 deg. at maximum speed was observed in two groups of college men ($n = 35$ and 30). Arm length and the effective mass of the arm as reflected at the knuckles were measured. Lateral static adduction strength at the same reference point was also determined. All variables showed highly reliable individual differences ($r = .92$ or higher before correction). Substitution of the measured values of time, mass, and distance moved, into the standard physical formula for linear acceleration, yielded individual estimates of the muscular force exerted during the movement.

The correlation between individual differences in muscular force estimated by the formula and measured statically with a dynamometer was $r = .172$ in one group of subjects and .208 in the other. Individual ratios of strength to arm mass failed to correlate significantly with speed of movement ($r =$ —.039 and —.160). Another method, avoiding assumptions as to linear acceleration, yielded correlations of $r = .099$ and —.175 between movement time and measured strength with arm mass held statistically constant. The average muscular force estimated from the linear acceleration formula was 8.9 kg. in the first group and 6.1 in the second, compared with 15.5 and 16.8 kg. of measured static strength. The correlation between reaction time and movement time was not significant ($r = .059$).

The lower values of estimated force during movement were accounted for by the hypothesis that acceleration in the arm movement was chiefly ballistic rather than linear. A tentative mathematical model was proposed that involves reasonable values for muscular force, movement time, and acceleration. Absence of appreciable correlation between static strength and computed force, or between the force-mass ratio and speed, was explained by the hypothesis that different neuromotor coordination patterns control static muscular strength and strength in action. Consideration of other known facts concerning the specificity of individual differences in neuromotor coordination abilities would indicate that the correlation between the two types of strength would be expected to be low.

The results of the two experiments support the conclusion that individual differences in static strength cannot predict "strength in action," in particular

as it is exhibited by maximal speed of movement in a 90 deg. horizontal arm swing from the shoulder pivot. Neuromuscular control patterns are apparently specific and different when the muscle is moving a limb as compared with causing simple static tension. The data strongly suggest that the acceleration curve for the arm movement is predominantly ballistic rather than linear. Further research on the nature of the acceleration curve is indicated.

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A Report on the Kraus-Weber Test in East Pakistan

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Abstract

This paper presents results of the Kraus-Weber Test for Minimum Muscular Fitness which was conducted in East Pakistan. A total of 2325 Pakistani male and female school children were subjects. The results were compared with reports of the original tests in the United States and Europe. The testing program revealed that Pakistani children were less able than European children in passing the six test items. They were, however, more successful than American children included in the original report of the Kraus-Weber Test.

SINCE 1953 the results of various Kraus-Weber tests in the United States and European countries have been recorded. In 1958 the test was conducted in East Pakistan. Subjects were 1195 boys and 1130 girls. The results of this testing program can now be added to the data on the Kraus-Weber test collected elsewhere. Two major purposes were considered.

1. To provide data on the Kraus-Weber Test from an Asian country.
2. To provide data for the Educational Directorate of East Pakistan to encourage upgrading of physical education and sports in the province.

Procedure

The procedure and techniques followed in the original tests in America and Europe (2) were employed in the East Pakistan program. Because education in East Pakistan is considerably different from that in the United States, some special considerations were essential.

A problem concerning the ages of children was encountered. In East Pakistan the date of birth of children is seldom recorded. In the vast majority of cases in this study, it was impossible to determine accurately the correct age of the subjects. A study of the school registers failed to clarify the problem, for most often the date of birth was omitted. Headmasters and headmistresses stated that parents seldom knew the date of birth of their children. After considerable effort to discover true ages it was decided that any recorded date was a rough guess and that exactness in this matter was impossible. Furthermore, the results of the test would be more meaningful in East Pakistan if the results were reported in terms of class divisions.

In East Pakistan it is customary to enroll a child in Class I at the age of five or six years. There are ten class divisions in the public education system. Therefore a child in Class I would normally be five and one-half or six years old, Class II children six or seven, and so on through Class X at which time

the age range would normally be from 14 to 16 years. These divisions roughly correspond to the age range of children tested in America and European countries.

Seven members of the staff at the Government College of Physical Education in Dacca were instructed in the exact techniques for administering the tests and in the criteria for judging each test. A practice session was held with student subjects taking the tests. Instructions described in the report by Kraus and Hirshland (2) were followed.

Approximately equal numbers of boys and girls were sought in the schools providing the subjects. Headmasters and headmistresses were notified that the testing team would visit their schools at a scheduled time. The nature of the test was not revealed in advance, and the testing was not proceeded by practice or warm-up. Subjects were enrolled in boys and girls primary and secondary schools in Dacca, Narayanganj, and Mymensingh.

When the testing team arrived at a school, two of the team appeared before the classes from which random numbers of children were taken to explain the test items, show posters illustrating the tests, and demonstrate each test. Explanations were given in Bengali. In the testing room one of the staff gave directions and, when appropriate, recorded time. Five to seven students were tested simultaneously and each had a tester observe the performance.

Six items in the test battery were given, in the order shown in Figure I.

As the testing program progressed in the schools, 73 subjects were taken at random and re-tested. This was done to check the reliability of the testing. The coefficient of reliability between the original and re-test was .851 $\pm$ .042.

Analysis of the Data

The raw data collected included test results of 1195 boys and 1130 girls, a total of 2325 subjects. Although this is a small percentage of the total numbers of children in East Pakistan schools, it is considered to be a representative group, since random selection was made in numerous schools in different sections of the province. The raw data appear in Table 1.

The percentage of failures are shown in Table 2. The table shows that among boys there was a general trend toward improvement as age increased. The range of the percentage of failure was 19.70 per cent in Class X to 61.67 percent in Class I. Among girls there was a greater percentage of failure at all class stages. The range for girls was a low of 43.07 percent in Class IX to a high of 69.05 percent in Class I. The mean percentage of failure for boys was 35.87 percent; for girls 56.56 percent.

These figures reveal the classes (ages) where deficiencies exist and point out where attention is most likely needed. They also indicate that girls at all stages might improve in muscular fitness if a program of physical education were a regular part of their school experience. The girls, particularly, were well below expected standards. Similarily, the results of the boys' tests reveal a need for attention in Classes I to VI particularly.

It is noted that the areas where greatest deficiencies lie are the most neglected in the provisions for physical education training in East Pakistan

TABLE 1.—RAW DATA FROM THE KRAUS-WEBER TEST IN EAST PAKISTAN

FAILURES BY BOYS

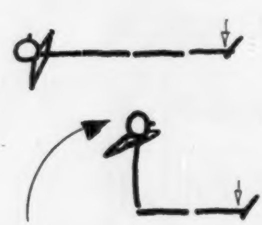
		Test Item Failed						Number of Test Items Failed						
		Test												
Class	N	1	2	3	4	5	6	None Failed	1 Test Failed	2 Tests Failed	3 Tests Failed	4 Tests Failed	5 Tests Failed	6 Tests Failed
I	102	29	46	8	1	18	27	39	24	19	13	7	0	0
	%	28.4	45.1	7.8	.9	17.6	26.5	38.2	23.5	18.6	12.3	6.9	0	0
II	118	25	38	4	0	6	21	63	27	18	9	1	0	0
	%	21.2	32.2	3.4	0	5.1	17.8	53.3	22.8	15.2	7.6	.08	0	0
III	121	27	37	7	1	16	21	57	30	24	9	1	0	0
	%	22.3	30.6	5.8	.8	13.2	17.4	47.1	24.8	19.8	7.4	.08	0	0
IV	102	15	24	5	0	7	14	62	24	10	4	1	1	0
	%	14.7	23.5	4.9	0	6.9	13.7	60.8	23.5	9.8	3.9	.09	.09	0
V	129	10	19	7	2	15	18	89	21	10	6	3	0	0
	%	7.8	14.7	5.5	1.6	11.6	14.0	69.0	16.3	7.8	4.7	2.3	0	0
VI	116	7	12	6	1	12	22	73	31	8	3	1	0	0
	%	6.0	10.3	5.2	.9	10.3	19.0	62.9	26.7	6.9	2.6	.08	0	0
VII	117	1	5	8	0	11	15	88	21	5	3	0	0	0
	%	.9	4.3	6.8	0	9.4	12.8	75.2	17.9	4.3	2.6	0	0	0
VIII	115	3	5	6	3	9	16	90	16	4	3	1	1	0
	%	2.6	4.3	5.2	2.6	7.8	13.9	78.3	13.9	3.5	2.6	.09	.09	0
IX	138	1	3	6	1	15	17	105	25	6	2	0	0	0
	%	.7	2.2	4.3	.7	10.9	12.3	76.1	18.1	4.3	1.4	0	0	0
X	137	1	2	1	0	9	19	110	22	5	0	0	0	0
	%	.7	1.5	.7	0	6.6	13.9	80.3	16.1	3.6	0	0	0	0
Total	1195	119	191	58	9	118	190	776	241	109	52	15	2	0
	%	10.0	16.0	4.9	.008	9.9	15.9	64.9	20.2	9.1	4.4	.01	.002	0

FAILURES BY GIRLS

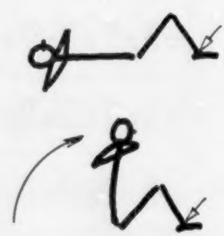
I	84	25	44	7	3	25	22	26	21	19	11	3	2	2
	%	29.8	52.4	8.3	3.6	29.8	26.1	31.0	25.0	22.6	14.0	3.6	2.4	2.4
II	96	37	50	5	1	14	22	34	19	25	14	2	2	0
	%	38.5	51.5	5.2	1.0	14.6	22.9	25.4	19.8	26.0	14.6	2.1	2.1	0
III	77	24	31	10	0	12	16	26	25	12	12	2	0	0
	%	31.2	40.3	13.0	0	15.6	20.8	33.8	32.5	15.6	15.6	2.6	0	0
IV	114	36	52	8	1	20	12	47	22	31	11	3	0	0
	%	31.6	45.6	7.0	.9	17.5	10.5	41.2	19.3	27.2	9.6	2.6	0	0
V	153	39	56	18	0	21	13	75	35	24	12	7	0	0
	%	25.5	36.6	11.8	0	13.7	8.5	49.0	22.9	15.7	7.8	4.6	0	0
VI	153	28	48	26	0	30	12	72	38	27	12	4	0	0
	%	18.3	31.4	17.0	0	19.6	7.8	47.0	24.8	17.6	7.8	2.6	0	0
VII	153	44	68	16	1	23	18	65	31	37	15	5	0	0
	%	28.8	44.4	10.5	.7	15.0	11.8	42.5	20.3	24.2	9.8	3.3	0	0
VIII	89	15	29	7	0	5	9	45	26	15	3	0	0	0
	%	16.9	32.6	7.9	0	3.4	10.1	50.6	29.2	16.9	3.4	0	0	0
IX	130	23	39	11	0	6	18	74	25	24	5	1	1	0
	%	17.7	30.0	8.5	0	4.6	13.8	56.9	19.2	18.5	3.8	.76	0	0
X	81	16	30	5	1	9	16	38	22	8	13	0	0	0
	%	19.8	37.0	6.2	1.2	11.1	19.8	46.9	27.2	9.9	16.0	0	0	0
Total	1130	287	447	113	7	165	158	502	264	222	108	27	5	2
	%	25.4	36.0	10.0	.006	14.4	14.0	44.4	23.4	19.6	9.6	2.4	.004	.002

schools. Few girls schools in the province, if any, have a regular program of physical education. Most boys schools have a program, usually of a cursory nature, and the older boys who take part in games and sports are the ones who benefit most. These facts are of importance in accounting for deficiencies of all girls and younger boys.

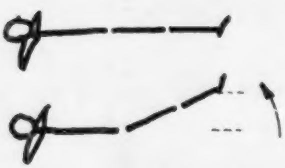
Table 1 points out the number of failures in specific tests which occurred with the greatest frequency.



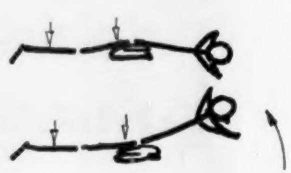
1. Tests abdominal and psoas strength.



2. Further test for abdominals.



3. Tests psoas and lower abdominal strength.



4. Tests strength of upper back muscles.

5. Tests strength of lower back muscles.

6. Tests length of back and hamstring muscles.

FIGURE I. Test items in the Kraus-Weber test for minimum physical fitness.

TABLE 2.—PERCENTAGE OF FAILURE OF PAKISTANI CHILDREN BY CLASS AND SEX

Class	Percentage of Failures			
	Boys		Girls	
	Percent	σ P	σ Percent	P
I	61.76	±4.82	69.05	±5.36
II	46.61	±4.59	64.58	±4.87
III	52.89	±4.54	66.23	±5.39
IV	39.21	±4.83	58.77	±4.61
V	31.[illegible]	±4.07	50.98	±4.27
VI	37.06	±4.48	52.94	±4.02
VII	24.78	±3.99	57.51	±3.65
VIII	21.73	±3.84	49.43	±4.37
IX	23.91	±3.48	43.07	±4.34
X	19.70	±3.40	53.08	±5.55

Further study of this table will disclose excessive failures by boys in the abdominal tests (#1 and #2), in lower back (#5), and flexibility (#6). Boys performed well in the test requiring strength of the upper back muscles (#4). Most significant is the fact that 62.53 percent of all failures by boys occurred in the primary grades (Classes I to V) which indicates the general poor muscular fitness of these younger boys.

The girls portion of Table 1 shows general poor performance in the abdominal tests (#1, #2, #3) and lower back (#5). Girls were somewhat better than boys in the flexibility test, but their record in test #6 is unsatisfactory by the standards of European girls. Like the boys they performed best in the upper back test. Girls in Classes I to V accounted for 50.32 percent of the failures; unlike the boys' performance, their record reveals practically no improvement as age increased.

Figure 2 discloses graphically where the muscular weaknesses lie, as revealed by the Kraus-Weber test. The figure shows the abdominal, back, and flexibility failures by percentage of failure for boys and girls as well as the total group. It shows that abdominal strength deficiencies exist among both boys and girls. The girls exhibited particular weakness here; 71.96 percent failed one of these three tests. The boys are also well below expectations. Table 1 shows that most of the failures in these three tests occurred in Classes I to V. About 82 percent of the older boys (Classes VI to X) passed the tests of abdominal strength successfully.

When the entire sample of all boys and girls is considered separately, the boys have a better record than girls in the lower back test (#5), and the performance of the girls in the upper back test (#4) was slightly better. The girls were somewhat better than boys in flexibility.

Comparison with American and European Children

Figure 3 shows a comparison of the Pakistani children with similar groups in United States and Europe as revealed in the Kraus-Hirschland report. This table shows that Pakistani children performed better at some stages than

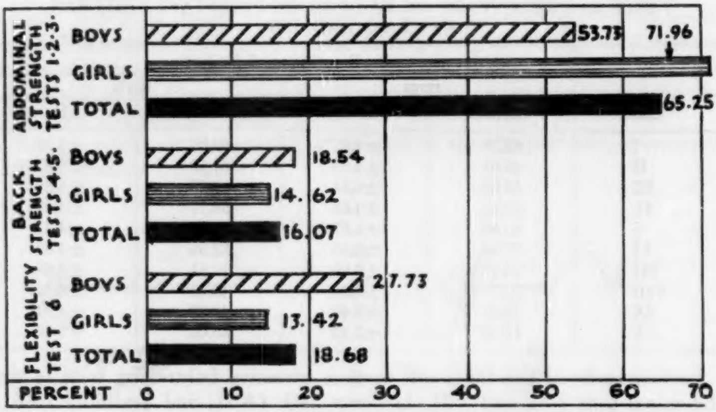


Figure II. Percentage of failures in abdominal, back, and flexibility tests.

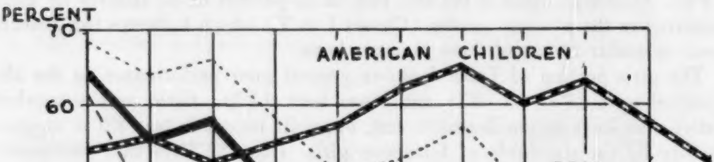


Figure III. Percentage of test failures; comparison of Pakistani, European, and American children.

American children but that their performance was considerably poorer than European children. Study of other tests conducted with American children as subjects would alter this figure somewhat, usually with advantage to the American groups (1, 3, 4).

Superimposed on Figure 3 are lines representing the percentage of failure of Pakistani boys and girls. It is noted that the line representing the boys shows considerable improvement with age. The line representing Pakistani girls fluctuates some but generally stays at a high percentage of failure and, at the oldest level, is moving toward an even higher percentage of failure.

In the Kraus-Weber test a child is judged to have less than minimum muscular fitness if he fails in one or more of the test items. In the testing program in East Pakistan many children missed one or more of the tests. On the basis of this test a serious lack of minimum muscular fitness is indicated.

The results of the test in East Pakistan (as well as those conducted in Europe) should cause serious concern for the physical status of American school children as well as of Pakistani children. The children tested in East Pakistan seldom have any of the opportunities of American children. Their school facilities, the teachers, the play and recreation opportunities, and play areas are unbelievably inferior. The diet of all children in East Pakistan, except perhaps the children of the very wealthy, is completely unsatisfactory for robust health. The health and sanitary standards often lead to illnesses which drain vitality and sap strength. Particularly prevalent are dysentery, malaria, small pox, and cholera. The hot, excessively humid weather is a serious deterrent. In spite of these astonishing deficiencies the children of East Pakistan proved to be superior to the American children in passing the six items on the Kraus-Weber test battery.

Conclusions

The first physical test in East Pakistan has revealed some very important and serious deficiencies which should be given immediate attention. It was pointed out to the Educational Directorate of the province that the physical status of the school children was not as good as it should be.

The following are the most obvious conclusions revealed by the test in East Pakistan.

1. The over-all minimum muscular fitness of boys and girls is below the standard of European children.

2. Boys below the sixth class are generally lacking in minimum muscular fitness.

3. There were fewer failures among older boys in classes VII to X than in any other group. This may be due to their greater opportunity to take part in games and sports. These activities are generally more available to this age group.

4. Abdominal weakness was most pronounced among both boys and girls. As a whole the girls were slightly superior to the boys in back strength and flexibility. These results varied some in different classes.

5. There was a greater number of failures among younger boys. This fact may be used to emphasize the need to extend physical education downward into the lower grades in East Pakistan.

6. Girls at all class levels had a high percentage of failures. A program of physical education for girls at all class stages seems most essential. The girls were most deficient. No program of physical education of any consequence is now being conducted in the girls' schools.

7. Comparison with the data from the original Kraus-Hirshland report showed that the Pakistani children were less able than European children but somewhat better than American children.

8. Future testing in East Pakistan in physical education and in education will be difficult until accurate records of ages of children are maintained in the school records.

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Pulse Wave and Blood Pressure Changes Occurring during a Physical Training Program

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Abstract

Members of the Santa Barbara basketball team were tested periodically during and after the 1957-58 season of play. The changes in physical conditioning were estimated using a step test. During this period of time the blood pressure and pulse wave measurements were studied to investigate the effects of basketball conditioning on these measurements.

The resting and postexercise systolic blood pressure measurements decreased significantly during training. These changes were significant after 16 weeks, while the pulse rate changes indicated conditioning had changed in six weeks. During de-training these measurements reversed and made significant changes in ten weeks.

The pulse wave measurements more closely followed those of the step test. They changed significantly in six weeks, leveled off, and finally reversed to the starting level during de-training.

PHYSICAL EDUCATORS have been experimenting for many years, comparing athletes with nonathletes and testing athletes before and after training but have done very little work following the changes in the circulation periodically during training. This study was done to investigate periodic blood pressure changes occurring during and after a season of basketball play at the college level.

Many studies (1, 2, 3, 7, 12, 14) have indicated that the recovery pulse rate can be used to estimate the degree of physical conditioning brought about through exercise. Using a step test reported previously (11) as an indication of the changes in levels of conditioning occurring during several weeks of physical training, this investigation followed the peripheral pulse curve and blood pressure measurements taken durng the same period of time. These measurements of pressure have been reported to estimate the strength of the heart contraction and cardiac work (15, 16).

Procedure

Seventeen members of the Santa Barbara varsity basketball team were used as subjects. They ranged in age from 19 to 26 years. Their weights ranged from 139 to 223 lb. and heights from 68.5 to 77.5 in.

The blood pressure measurements were taken by auscultation using a mercury manometer. The pulse wave was obtained indirectly from the

brachial artery using a Cameron Heartometer.[1] All pressures were taken on the left arm by one of the investigators. The climatic conditions were very stable in Santa Barbara with laboratory temperatures varying from 76°F to 78°F.

The procedure for using the Heartometer has been described by Cureton (3). To allow for variation due to cuff tightness and individual blood pressure differences, the air within the cuff was adjusted between diastolic and systolic pressures until the largest wave was produced. At this cuff pressure (usually around 80 mm Hg.) a 30-sec. recording of the pulse wave was taken. A representative wave was then selected and measured (see Figure 1). The

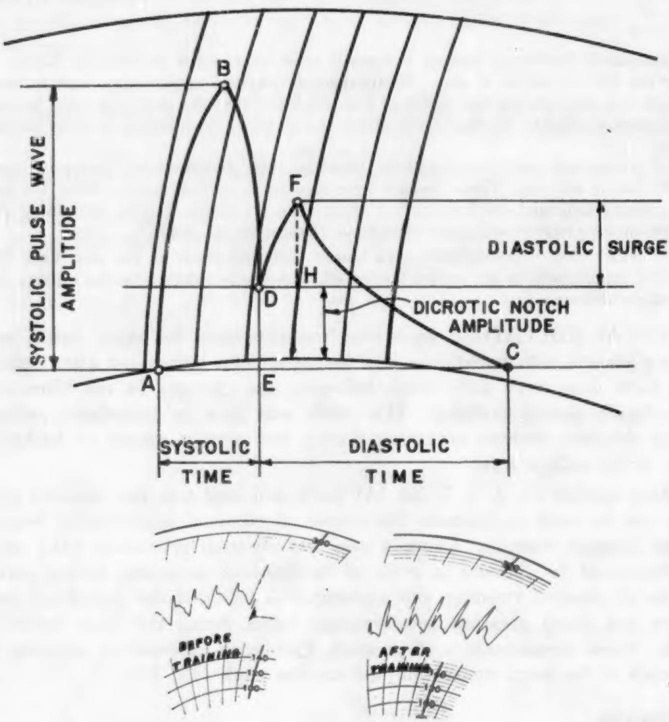

FIGURE I. Pulse wave with parts labeled and sample of actual wave before and at end of training.

[1] Made by the Cameron Heartometer Co., 656 W. Division St., Chicago, Illinois.

TABLE 1.—DAY TO DAY VARIABILITY OF THE TESTS RESTING AND FOLLOWING A ONE-MINUTE STEP TEST (N=17)

	Resting			Immediately After			1 min. after			2 min. after			3 min. after			4 min. after			5 min. after		
	Mean Diff.	σ d	r	Mean Diff.	σ d	r	Mean Diff.	σ d	r	Mean Diff.	σ d	r	Mean Diff.	σ d	r	Mean Diff.	σ d	r	Mean Diff.	σ d	r
Pulse Rate Sum	8.6	6.6	.72																		
Sys. B.P.	1.2	1.6	.72	3.6	6.1	.66	4.0	4.6	.59	2.0	5.4	.64	1.8	2.5	.65	2.2	2.3	.78	1.0	3.1	.59
Dias. B.P.	2.1	2.3	.45	2.2	3.2	.43	4.2	2.7	.54	2.4	2.5	.46	1.6	2.1	.40	1.2	2.0	.50	2.4	1.6	.48
Sys. Amp.	.12	.05	.73																		
Dias. Notch	.01	.04	.61																		
Dias. Surge	.04	.05	.63																		
Sys. Amp./Sys. time	.81	.45	.68																		

subjects were tested between 2:00 and 4:00 p.m., in the laboratory, at least two hours away from a meal. The sitting blood pressure and pulse wave measurements were taken after the subject had rested from five to ten minutes and the pulse rate and blood pressures had leveled off. The sphygmomanometer cuff was placed on the left arm so that the lower edge came within 1 inch of the bend at the elbow. The cuff was kept on the arm and used for both the blood pressure and pulse wave measurements. The subject then stepped on a 17-in. bench for one minute at the rate of 36 steps per minute. The sitting blood pressure measurements were taken immediately after the exercise ended and at each minute during the next five minutes of recovery. The pulse rate was recorded each time the blood pressure was measured, and the recovery count was used as an index of conditioning. This series of tests was given at the beginning of the basketball practice in October, and again each three weeks during the 16-week season ending in February. Sixteen of the members were tested in May after 10 weeks of de-training, and 14 of the subjects were measured again in September after 30 weeks of de-training. There was a break in training during three weeks in January because of final examinations.

Day to Day Fluctuations of the Measurements. The subjects were tested twice before training began in October with three to six days between tests to show the variability of the measurements. The differences and reliability coefficients are shown in Table 1. The reliability coefficients are on the same order as those reported by Henry (6) and Massey (9). Since the Heartometer instrument is influenced by pressure changes in the air cuff and positioning on the arm, great care was taken to standardize the procedure. The same instrument was always used, and Heartometer pressures were checked with mercury columns from time to time to standardize the pulse waves.

Results

The Recovery Pulse Rate. The changes in conditioning are shown by the recovery pulse rate[2] in Figures II and III. The lower pulse rate sum indicates better conditioning with the faster recovery. The results indicated that significant changes in conditioning occurred between October and November (three weeks), and continued until the season ended in February. As shown in Figure II, there was a leveling off of the pulse rate in December after six weeks of training. The pulse rate reversed, though not significantly, during the three-week break in training in January, then reversed to a maximum change in February, after three additional weeks of training. It appears then that after three to six weeks of conditioning, physiological changes as reflected by the heart rate reach a plateau that is maintained when work of the same magnitude is continued.

[2]The sum of the one minute, two minute, and three minute 15-second pulse counts multiplied by four to convert to rate/minute. The pulse counts were taken following a 1 minute step test on a 17-inch bench at 36 steps/minute. This sum was used to indicate the fitness level of the subjects.

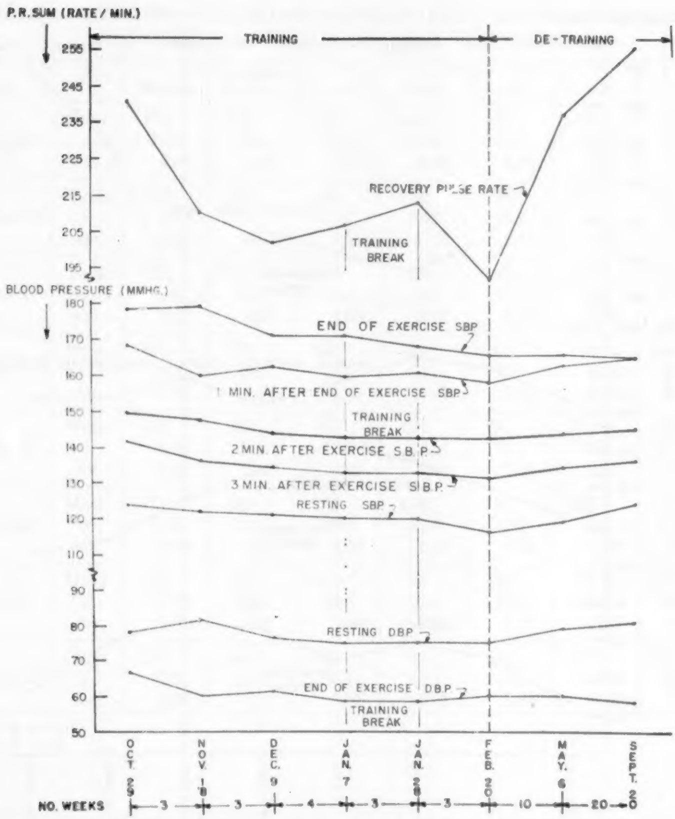

FIGURE II. Results of a one minute step test given during training and de-training. The sum of the one, two, and three minute pulse rate recovery counts is shown at the top of figure. Below this are the resting and recovery blood pressure measurements that made significant changes during training.

Blood Pressure Measurements. The resting systolic pressure measurement decreased from 124 mm Hg., in October to 117 in February. This change was significant at the .05 level.[8] The systolic pressure taken immediately after exercise and during recovery from exercise, decreased around 8–10 mm. Hg.,

[8] Since paired data was used, the difference method was used to find the t to take into account the correlation factor.

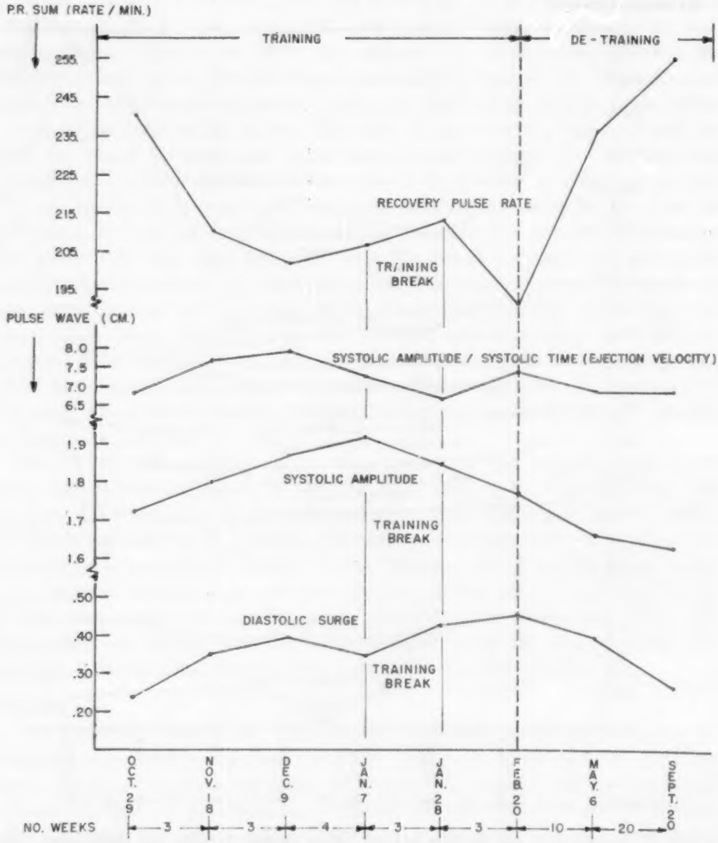

FIGURE III. At the top of the figure are the results of the one minute step test using the sums of the one, two, and three minute recovery pulse counts as an indication of conditioning. Below this graph are the pulse wave measurements that changed significantly during training.

between October and February. These changes are significant at the .05 level (see Tables 2 and 6).

The blood pressure measurements taken at three, four, and five minutes after exercise decreased so that the changes reached the .05 level of significance by January, after ten weeks of training. The systolic pressure after exercise did not recover to the resting level within five minutes, as the pulse rate did during training.

TABLE 2.—MEAN SYSTOLIC BLOOD PRESSURE DATA (mm Hg) BEFORE AND FOLLOWING A ONE-MINUTE STEP TEST (N=17)

Date		Resting	Immediately After	1 min.	2 min.	3 min.	4 min.	5 min.
Oct. 29	Mean	124	178	168	150	142	135	132
	σ	10.6	18.6	15.7	18.8	14.6	14.5	11.9
	σm	2.65	4.65	3.92	4.70	3.65	3.65	2.98
Nov. 18	Mean	122	179	160	148	137	132	127
	σ	8.04	16.2	17.8	15.1	14.8	11.4	8.38
	σm	2.01	4.05	4.46	3.78	3.71	2.85	2.10
Dec. 9	Mean	121	171	163	145	138	132	129
	σ	8.67	18.5	14.2	18.8	17.0	13.3	13.1
	σm	2.17	4.62	3.56	4.70	4.24	3.32	3.29
Jan. 7	Mean	120	171	160	144	136	128	125
	σ	6.9	18.6	17.8	15.7	10.6	8.95	7.98
	σm	1.72	4.66	4.45	3.92	2.65	2.24	1.99
Jan. 28	Mean	120	168	161	144	136	130	128
	σ	8.22	23.8	20.9	15.6	13.9	10.8	15.1
	σm	2.06	5.95	5.22	3.89	3.49	2.71	3.80
Feb. 20	Mean	117	167	158	143	134	127	123
	σ	11.6	17.7	20.9	18.4	15.5	13.6	11.3
	σm	2.90	4.42	5.23	4.60	3.88	3.40	2.83
May 6[a]	Mean	119	167	163	148	138	132	127
	σ	7.76	24.2	22.7	21.3	17.8	14.2	12.0
	σm	1.94	6.05	5.67	5.32	4.45	3.56	3.01
Sept. 20[b]	Mean	124	165	165	149	140	133	130
	σ	10.9	25.2	20.4	16.9	13.9	11.8	10.4
	σm	3.03	7.0	5.67	4.71	3.86	3.28	2.88

[a] N = 16
[b] N = 14

The recovery curve for the systolic blood pressure measurements did not change during training as did the pulse rate. The pulse rate recovery curve dropped more rapidly after six weeks of training (11).

Figure II shows the blood pressure measurements that made significant changes during training. Since the systolic pressure changes at the four and five minute recovery times paralleled those at three minutes, they are not shown.

The diastolic pressure measurement (fourth phase), taken immediately after exercise, decreased between October and November (see Table 6). This change was significant and remained significant throughout the training period. There was no other consistent significant change in the diastolic pressure measurement during training. The diastolic pressure had nearly recovered to the resting level by the end of the third minute following exercise

regardless of the training program. This measurement did not change in a manner that paralleled the pulse rate change.

The pulse pressure measurements decreased only slightly during the training and no consistent pattern of significance was seen in this change. During de-training, the resting systolic and diastolic pressures made changes that reversed significantly to the October level (see Table 7). The blood pressure measurements taken during recovery did not reverse significantly during de-training. None of the combinations of blood pressure measurements changed significantly during training (see Table 5).

Brachial Pulse Wave Measurements. Figure I shows the enlarged pulse wave and an example of a typical pulse wave, with the changes that occurred in the majority of cases, i.e., significant changes, before and after training.

The systolic amplitude (Figure III) made maximum changes after ten weeks of training, then reversed until the end of the experiment. Tables 8 and

TABLE 3.—MEAN DIASTOLIC BLOOD PRESSURE DATA [a](mm Hg) BEFORE AND FOLLOWING A ONE-MINUTE STEP TEST (N = 17)

Date		Resting	Immediately After	1 min.	2 min.	3 min.	4 min.	5 min.
	Mean	78	66	73	74	76	74	77
Oct. 29	σ	7.01	8.99	8.86	9.02	8.1	7.19	8.2
	σm	1.75	2.25	2.22	2.26	2.02	1.80	2.05
	Mean	82	60	73	76	75	77	78
Nov. 18	σ	7.34	11.9	10.6	9.27	8.95	7.14	7.17
	σm	1.84	2.97	2.64	2.32	2.24	1.78	1.79
	Mean	77	61	74	74	75	75	76
Dec. 9	σ	6.16	12.6	10.2	8.18	8.55	9.04	7.97
	σm	1.54	3.15	2.55	2.04	2.14	2.26	1.99
	Mean	76	59	72	72	74	73	74
Jan. 7	σ	8.91	9.52	7.44	7.01	9.16	6.72	8.32
	σm	2.23	2.38	1.86	1.75	2.29	1.68	2.08
	Mean	75	58	74	73	74	74	73
Jan. 28	σ	9.20	1.04	7.30	8.85	9.06	8.12	6.83
	σm	2.30	2.61	1.83	2.25	2.26	2.03	1.72
	Mean	75	60	70	73	71	72	73
Feb. 20	σ	6.69	8.59	6.74	7.20	6.35	7.10	6.34
	σm	1.67	2.14	1.68	1.80	1.59	1.77	1.58
	Mean	77	60	73	74	74	75	76
May 6[b]	σ	8.34	10.4	11.2	7.82	7.96	8.18	7.60
	σm	2.08	2.59	2.80	1.95	1.99	2.04	1.90
	Mean	80	57	72	74	77	77	76
Sept. 20[c]	σ	7.32	11.7	5.65	6.57	5.85	5.12	4.94
	σm	2.03	3.25	1.57	1.82	1.62	1.42	1.37

[a] 4th Phase diastolic
[b] N = 16
[c] N = 14

TABLE 4.—PULSE PRESSURE DATA (SBP-DBP) BEFORE AND FOLLOWING A ONE-MINUTE STEP TEST (N = 17)

Date		Resting	Immediately After	1 min.	2 min.	3 min.	4 min.	5 min.
	Mean	46	112	95	76	66	61	55
Oct. 29	σ	14.9	16.2	17.1	19.8	15.2	16.5	10.4
	σm	3.72	4.04	4.28	4.95	3.81	4.12	2.61
	Mean	40	119	87	72	62	55	49
Nov. 18	σ	10.5	17.1	19.9	20.8	21.5	12.8	10.4
	σm	2.65	4.28	4.99	5.19	5.38	3.20	2.59
	Mean	44	110	89	71	63	57	53
Dec. 9	σ	10.9	23.5	19.2	20.2	17.9	13.5	12.6
	σm	2.73	5.87	4.79	5.05	4.48	3.38	3.16
	Mean	44	112	88	72	62	55	51
Jan. 7	σ	10.9	21.9	19.5	18.0	13.0	9.50	8.62
	σm	2.72	5.49	4.89	4.50	3.25	2.38	2.16
	Mean	45	110	87	71	62	57	55
Jan. 28	σ	10.4	28.2	26.0	19.7	16.7	14.7	10.5
	σm	2.59	7.05	6.35	4.92	4.18	3.68	2.62
	Mean	42	107	88	70	63	55	50
Feb. 20	σ	13.6	25.3	22.1	19.6	16.2	14.4	13.6
	σm	3.39	6.33	5.52	4.91	4.05	3.60	3.40
	Mean	41	107	90	74	63	57	52
May 6[a]	σ	11.1	23.5	29.8	26.5	18.1	15.7	13.7
	σm	2.77	5.89	7.44	6.62	4.52	3.94	3.42
	Mean	44	107	93	75	63	57	52
Sept. 20[b]	σ	11.2	28.7	20.7	15.2	13.6	10.8	10.8
	σm	3.11	7.97	5.75	4.24	3.78	3.01	3.01

[a] N = 16
[b] N = 14

9 show that the systolic amplitude increased from 1.72 to 1.92 cm between October and January, then began to decrease to below the October level until it reached an average of 1.63 cm in September. The changes reached the .05 level of significance by December and the .01 level in January (see Table 9). The system amplitude measurement did not follow that of the pulse rate in that there was no plateau after six weeks. Once the amplitude began to decrease it never reversed as did the pulse rate. Between January and September, the systolic amplitude measurements reversed. These changes were significant at the .01 level of significance.

The systolic amplitude has been reported by Massey (16), Cureton (5), and Henry (9) to differentiate athletes and nonathletes. The diastolic surge made significant changes in six weeks between October and December, and continues until February. This measurement paralleled the pulse rate test and

TABLE 5.—COMBINATIONS OF BLOOD PRESSURES BEFORE AND FOLLOWING A ONE-MINUTE STEP TEST (N = 17) (mm Hg)

Date	Resting	Immed. After	1 min.	2 min.	3 min.	4 min.	5 min.
	MEAN PRESSURE ⅓ (SBP DEP)						
Oct. 29	95	122	120	120	109	104	104
Nov. 18	102	120	116	112	106	106	102
Dec. 9	99	116	118	110	106	104	102
Jan. 7	98	115	116	108	105	100	100
Jan. 28	98	113	118	108	105	102	100
Feb. 20	96	114	114	108	102	100	98
May 6[a]	98	120	118	111	106	104	102
Sept. 20[b]	102	111	119	112	108	105	103
	PULSE PRESSURE/MEAN PRESSURE						
Oct. 29	.45	.92	.79	.63	.60	.59	.53
Nov. 18	.39	.99	.75	.64	.58	.53	.48
Dec. 9	.44	.95	.75	.64	.59	.55	.52
Jan. 7	.45	.97	.76	.67	.59	.55	.51
Jan. 28	.46	.97	.74	.66	.59	.56	.55
Feb. 20	.44	.94	.77	.65	.62	.55	.51
May 6[a]	.43	.89	.76	.67	.60	.55	.50
Sept. 20[b]	.43	.96	.78	.67	.58	.54	.50
	STROKE VOLUME (93 + .54 PP —.47 DP—(.61 X age) Star Formula (14)						
Oct. 29	67.9	97.0	92.5	85.9	79.5	77.8	73.1
Nov. 18	62.5	115.7	92.3	82.8	77.8	73.1	69.4
Dec. 9	67.2	110.3	92.9	84.2	78.4	75.1	72.5
Jan. 7	67.6	112.2	93.3	84.6	78.2	75.0	72.3
Jan. 28	68.7	111.9	91.8	83.7	78.2	75.6	75.0
Feb. 20	67.0	109.2	94.3	83.1	80.2	75.5	72.3
May 6[a]	66.1	96.1	93.9	84.8	80.4	75.1	71.4
Sept. 20[b]	65.8	110.6	96.0	85.3	77.4	74.2	72.0

[a] N = 16
[b] N = 14

appears to be a good indicator of conditioning. The plateau after six weeks and the maximum change in February followed the pulse rate trend very well.

When training stopped, the surge like the pulse rate reversed and these changes were significant at the .01 level. The diastolic surge increased as the systolic pressure decreased. This would indicate that perhaps the vessel elasticity or resistance relates to the surge. Studies should be made of this phenomena.

The ejection velocity (Sys amp./Sys. Time) increased until December (.05 level) then leveled off to return to normal by May. This measurement also parelleled the pulse rate test very closely, (Figure III), reversing itself in December, and increasing again after an additional training period. The ejection velocity measurement appears to change at the same time that the recovery pulse rate curve changes direction.

TABLE 6.—MEAN DIFFERENCES AND T-RATIOS ON STEP TEST BETWEEN PRECONDITIONING IN OCTOBER AND MONTHS OF TRAINING (N = 17)

Date	Resting		Immediately After		1 min.		2 min.		3 min.		4 min.		5 min.	
	Diff.	t	Diff.	t	Diff.	t	Diff.	t	Diff.	t	Diff.	t	Diff.	t
SYSTOLIC BLOOD PRESSURE (mm Hg.)														
Oct.-Nov. 18	−2	.74	1	.38	−8	2.40[a]	−2	.59	−5	1.31	−3	.82	−5	1.81
Oct.-Dec. 9	−3	1.07	−6	1.07	−5	1.67	−5	1.18	−5	1.54	−3	.77	−3	.88
Oct.-Jan. 7	−4	1.52	−7	1.45	−8	1.63	−6	1.68	−6	2.22[a]	−7	2.18[a]	−7	2.42[a]
Oct.-Jan. 28	−4	1.50	−10	2.10	−7	1.35	−6	1.41	−6	1.75	−5	1.88	−4	.87
Oct.-Feb. 20	−7	2.78[a]	−11	2.44[a]	−10	2.13[a]	−7	2.18[a]	−8	2.60[a]	−8	2.99[b]	−8	3.65[b]
DIASTOLIC BLOOD PRESSURE (mm Hg.)														
Oct.-Nov. 18	4	2.18[a]	−6	2.62[a]	0	0	2	1.32	1	.44	3	1.48	1	.58
Oct.-Dec. 9	−1	.56	−5	1.51	1	.59	0	0	−1	.45	1	.49	−1	.45
Oct.-Jan. 7	−2	.73	−7	2.72[a]	−1	.54	−2	.95	−4	1.41	−1	.38	−3	1.22
Oct.-Jan. 28	−3	1.19	−8	2.93[a]	1	.53	−1	.58	−2	.90	0	0	−4	1.82
Oct.-Feb. 20	−3	1.64	−6	2.58[a]	−3	1.35	−1	.44	−5	2.27[a]	−2	1.02	−4	2.10
PULSE PRESSURE ½ (SBP + DBP)														
Oct.-Nov. 18	−6	2.11[a]	−7	2.36[a]	−8	2.44[a]	−4	1.19	−4	.86	−6	1.32	−6	2.40[a]
Oct.-Dec. 9	−2	.59	−2	.43	−6	1.88	−5	1.09	−3	.90	−4	.99	−2	.58
Oct.-Jan. 7	−2	.58	0	0	−7	1.43	−4	1.00	−4	.34	−6	1.48	−4	1.65
Oct.-Jan. 28	−1	.35	−2	.37	−8	1.54	−3	.73	−3	.83	−4	1.30	−2	.72
Oct.-Feb. 20	−4	1.08	−5	1.18	−7	1.48	−6	1.70	−3	.96	−6	1.95	−5	2.42[a]

[a].05 significance level
[b].01 significance level

TABLE 7.—MEAN DIFFERENCES AND T-RATIOS ON STEP TEST BETWEEN END OF TRAINING IN FEBRUARY AND MONTHS OF DE-TRAINING

Date	N	Resting		Immediately After		1 min.		2 min.		3 min.		4 min.		5 min.	
		Diff.	t	Diff.	t	Diff.	t	Diff.	t	Diff.	t	Diff.	t	Diff.	t
SYSTOLIC BLOOD PRESSURE (MMHg)															
Feb.-May	16	2	.76	0	0	5	1.23	5	1.34	4	1.02	5	1.29	4	1.14
May-Sept.	14	5	2.43[a]	—2	.26	2	.29	1	.16	2	.46	1	.32	3	.80
Feb.-Sept.	14	7	2.36[a]	—2	.29	7	1.04	6	1.59	6	1.36	6	1.87	7	2.94[a]
DIASTOLIC BLOOD PRESSURE (MMHg)															
Feb.-May	16	2	.95	0	0	3	.14	1	.54	3	1.51	3	1.53	3	1.81
May-Sept.	14	3	1.49	—3	.90	—1	.28	0	0	3	.92	2	.68	0	0
Feb.-Sept.	14	5	2.29[a]	—3	1.11	2	.90	1	.34	6	2.38[a]	5	1.88	3	1.42
PULSE PRESURE ½ (SBP + DBP)															
Feb.-May	16	—1	.26	—1	.18	2	.40	4	.98	0	0	2	.47	2	.53
May-Sept.	14	3	.82	1	.12	3	.34	1	.13	0	0	0	0	0	0
Feb.-Sept.	14	2	.56	0	0	5	.70	5	1.04	0	0	2	.68	2	.60

[a].05 significance level

TABLE 8.—BRACHIAL PULSE WAVE DATA DURING TRAINING
October-February and De-Training, March-September

Data	Oct. 29 N = 17	Nov. 18 N = 17	Dec. 9 N = 17	Jan. 7 N = 17	Jan. 27 N = 17	Feb. 20 N = 17	May 6 N = 16	Sept. 20 N = 14
SYSTOLIC AMPLITUDE (cm.)								
Mean	1.72	1.80	1.87	1.92	1.85	1.77	1.66	1.63
σ	.362	.366	.316	.345	.333	.254	.263	.234
σm	.0905	.0915	.0790	.0862	.0832	.0635	.0679	.0605
DICROTIC NOTCH (cm.)								
Mean	.56	.57	.63	.67	.58	.53	.47	.60
σ	.1385	.216	.130	.223	.190	.172	.139	.169
σm	.0346	.0540	.0325	.0558	.0462	.0430	.0359	.0468
DIASTOLIC SURGE (cm.)								
Mean	.24	.35	.39	.35	.42	.45	.39	.27
σ	.145	.131	.158	.109	.120	.175	.143	.167
σm	.0362	.0328	.0396	.0274	.0300	.0438	.0369	.0463
SYSTOLIC AMPLITUDE/SYSTOLIC TIME								
Mean	6.8	7.7	7.9	7.3	6.7	7.4	6.9	6.9
σ	1.36	1.31	1.68	1.60	1.21	1.44	1.08	1.32
σm	.340	.328	.420	.400	.300	.362	.279	.360

TABLE 9.—BRACHIAL PULSE WAVE DIFFERENCES AND T-RATIOS
Each Three Weeks During Training (N = 17)

	Oct.-Nov. 18	Oct.-Dec. 9	Oct.-Jan. 7	Oct.-Jan. 27	Oct.-Feb. 20
Systolic Amplitude (cm.)					
Mean Difference	.08	.15	.20	.13	.05
t	1.46	2.14[a]	3.09[b]	5.03	1.84
Diastolic Notch (cm.)					
Mean Difference	.01	.07	.11	.02	−.03
t	.20	2.26[a]	1.92	.373	.667
Diastolic Surge (cm.)					
Mean Difference	.11	.15	.11	.18	.21
t	2.67[a]	4.17[b]	2.94[b]	4.03[b]	4.20[b]
Systolic Amp./Systolic Time (ejection velocity)					
Mean Difference	.9	1.1	.5	.1	.6
t	2.73[a]	2.14[a]	1.15	.235	1.25

[a] .05 significance
[b] .01 significance

TABLE 10.—BRACHIAL PULSE WAVE DIFFERENCES AND T-RATIOS
During De-Training (February-September)

	Feb.-May (N = 16)	Feb.-Sept. (N = 14)	May-Sept. (N = 14)	Oct.-May (N = 16)	Oct.-Sept. (N = 14)
Systolic Amplitude (cm.)					
Mean Difference	−.11	−.14	−.03	−.06	−.09
t	2.01	1.47	.375	1.59[a]	1.24
Diastolic Notch (cm.)					
Mean Difference	−.06	.07	.13	−.09	.04
t	1.52	1.73	2.36[a]	1.70	.741
Diastolic Surge (cm.)					
Mean Difference	−.06	−.18	−.12	.15	.03
t	2.45[a]	3.34[b]	2.35[a]	3.20[b]	.775
Systolic Amp./Systolic Time (ejection velocity)					
Mean Difference	−.50	−.50	0	.10	.10
t	1.11	1.20	0	.308	.622

[a] .05 significance
[b] .01 significance

Discussion

Blood Pressure Measurements. The resting systolic blood pressure decreased gradually between October and February (see Figure II). This same decrease was reported by Cogswell (2), who noted the lowered blood pressure and pulse rate measurements during training. In both studies, the recovery from exercise measurements were lowered during training. At no time, however, did the systolic blood pressure return to normal within five minutes, and there was always a 50–55 mm Hg. rise due to the exercise. The diastolic pressure changes were significant only when taken immediately after exercise. Cogswell reported similar changes with this measurement. The one-minute postexercise diastolic pressure did not lower with training as in Cogswell's report, but similarly, it had returned to the resting value in three minutes. The drop in the diastolic pressure following exercise indicates a net decrease in peripheral resistance during training, but this occurs only during exercise, not at rest.

The pulse pressure measurements did not change significantly during training. This measurement is related to cardiac work, according to Starr (15), and not to cardiac output as thought by others. The results found here would indicate that the heart was working the same after training.

When we look at the combination of blood pressure measurements in Table 5, it is seen that very little change occurred with these measurements. Fraser (4) has pointed out that mean pressure, ½ (systolic plus diastolic pressure) does not show true mean pressure. Stevenson (17) indicated that true mean pressure is 1/3 (pulse pressure plus diastolic pressure). Using either formula we found no change in the mean pressure during training. The pulse pressure/mean pressure, an estimate of stroke volume, did not increase as it was thought might occur. Likewise, the stroke volume, using the Starr stroke volume formula, did not change (Table 5).[4] Either the stroke volume does not change with basketball playing or the estimates of stroke volume are not useful.

If the systolic pressure lowers during training while the stroke volume remains constant, then it is possible that the vascular elasticity or resistance has changed. Accepting the hypothesis that diastolic pressure relates to resistance and noting no drop during training, we would assume as has Henry (6) that there is probably an increase in elasticity with the training.

Pulse Wave Measurements. In using the Heartometer, there are several sources of error that must be taken into consideration. One error comes from the tightness of the cuff which will throw off the measurement and another is the amount of air in the cuff. The first factor was kept in mind by the tester

[4] After this report was submitted for publication, a recent article by P. J. Rasch, and others, *The Journal of the American Osteopathic Association* (58: 786; 1959) showed similar results with the Starr formula. Rasch used the number 99 in place of our 93; otherwise the formulas are identical.

each time he used the instrument. Cureton (3) suggests that by standardizing the pressure in the cuff at 80 mm Hg. air pressure, we can compare different persons. We have found less variability by adjusting the air in the cuff to each individual by changing the amount of air until the largest wave is found. This usually occurs around 80–90 mm Hg. cuff pressure and in this study changed only slightly with each test (2 mm Hg. average difference).

Studies have been reported showing that with direct pressure measurements the pulse wave amplitude relates to the stroke volume (13, 14, 17). Michael (10), showed this same thing to be true using the Heartometer pulse wave. Starr (16), however, has indicated that stroke work and not volume is related to the amplitude of the wave. Starr felt that the stroke work relates to the ejection velocity or steepness of the pulse wave slope. The velocity ejection can be estimated by dividing the systolic amplitude by the time of systole. This measurement increased significantly from 6.8 to 7.9 cm between October and December. The lack of change in the varied estimates of stroke volume would suggest that stroke work and not volume changed with training.

Summary

Seventeen members of the 1957-58 varsity basketball team were tested with a step test each three weeks during 16 weeks of training, again 10 weeks after de-training, and after 30 weeks of de-training. The resting pulse wave and blood pressure measurements and the postexercise blood pressure measurements taken after a step test were examined during this period of time. The results indicated the following:

1. The ejection velocity and diastolic surge measurements of the Heartameter paralleled the changes in the pulse rate recovery curve in reaching a plateau in December, after six weeks of training, and then improving again in February after six more weeks of training.
2. A minimal or absent diastolic surge was usually seen when conditioning was not being carried out.
3. The circulatory changes reflected by the pulse rate and Heartometer waves leveled off after four to six weeks of workout even though training continued.
4. The pulse rate and pressure curve measurements changed significantly in three to six weeks, while the systolic blood pressure measurements took up to 16 weeks to change significantly.
5. The resting systolic blood pressure measurement and the recovery measurements after exercise decreased significantly during 16 weeks of training.
6. The diastolic pressure taken immediately after exercise decreased significantly during training.
7. The mean pressure, pulse pressure, and other combinations of pressure measurements did not change during the time the pulse rate indicated conditioning was changing.

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(Submitted 5/25/59)

A Study of Differences in Selected Physical Performance Test Scores of Women in Tennessee Colleges[1]

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Abstract

The purpose of the study was to investigate the differences in physical performance test scores of women in Tennessee colleges as measured by selected tests. The subjects for this cross-sectional study were 720 women selected at random from 12 colleges and universities in Tennessee. The instrument used to measure the differences was a battery of selected physical performance tests which included a 40-yard speed and agility run, basketball throw for distance, sit-ups, standing broad jump, modified chins, bend forward for flexibility, and a 200-yard shuttle run. Results indicated that significant differences do occur in certain activities as performed by various groups of college women.

THIS STUDY investigated the differences in various components of physical performance of college women in the state of Tennessee by giving selected tests to freshmen, sophomore, junior, and senior women. Secondary problems of the study were to determine and analyze the physical performance scores of girls who played high school varsity basketball, those who had not played on a varsity team, those who were majoring in physical education, and those who were not majoring in physical education.

The basic hypothesis for this study was that there is no difference between college women in selected physical performance test scores during their four years in college. A secondary hypothesis was that physical education majors do not differ from nonmajors in their physical performance in selected tests, and that girls who had played high school varsity basketball do not differ in their level of performance in selected tests from girls who had not played on the varsity team.

Selection of Test Items

Test items included in the battery were selected from those frequently described in the literature on physical performance of college women: a dash (1,3,6,7,10,11,16,20), a dodging or obstacle run (4,6,12,16), a basketball throw for distance (2,4,11,13,15,16,21,23), a softball throw for distance (1,3, 6,10), a standing broad jump (1,3,6,10,13,15,16), sit-ups (2,12,13,14,15,17,

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[1]This study was carried out in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan.

19,20,22), modified chins (10,13,15,18), tests for flexibility (2,5,8,9,16,17), and a shuttle run (5,19,20,21). The literature disclosed that most of the research pertained to freshmen college women. Each test battery reported was different, yet most contained one or more identical items. After careful consideration of the various tests reported in the literature the writer decided that for the purposes of this study it would be best to devise a new battery. Keeping in mind such factors as validity, objectivity, administrative ease, simplicity, probable interest to the subject, purposes of the study, and probable physical condition of the subjects, the specific test items selected were as follows: 40-yard speed and agility run, basketball throw for distance, sit-up, standing broad jump, modified chin, bend forward for flexibiltiy, and a 200-yard shuttle run (see Appendix).

Methodology

The subjects used in this study were freshmen, sophomore, junior, and senior women regularly enrolled in selected private and state colleges in Tennessee. Colleges were selected so that state and private would be equally represented and so that approximately equal representation would be given to the geographic divisions of the state. The investigator and trained major assistants spent one day at each college and tested the subjects who had been selected at random from lists prepared by the registrar's office. Seven hundred and twenty college women participated in the study—180 from each of the four classes. Subjects took the entire battery in one testing period. The test was given under similar conditions in all colleges. The investigator operated the watch for the runs for all subjects who took the test.

Analysis of Data

The statistical computations used in this study were the mean, standard deviation, the significance of differences between the means, T scores, and the percentile rank of the T scores. The .05 level of significance was selected as an adequate level for rejecting the null hypothesis.

Findings

The following statements summarize the major findings from this study. Each of the statements was valid at the .05 level of confidence or better.

1. The freshmen had a higher level of performance in the 40-yard speed and agility run than the other classes. The difference between the freshmen and other classes was significant and increased for each additional year spent in college.
2. The freshmen had a higher level of performance in the sit-up test than the juniors and seniors. The difference was significant and increased for each additional year spent in college.
3. The sophomores had a higher level of performance than the juniors or seniors in the sit-up test. The difference was significant and increased for each additional year spent in college.

TABLE 1.—SUMMARY OF MEANS AND STANDARD DEVIATION

Participants	40-Yard Run (Seconds)		Basketball Throw (Feet)		Sit-up (Units)		Standing Broad Jump (Inches)		Modified Chin (Units)		Flexibility (Inches)		200-Yard Shuttle (Seconds)	
	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ
Freshmen	9.4	1.0	39	9.7	32	13.1	60	9.5	45	36.4	2.5	2.3	55.9	5.3
Sophomore	9.6	1.0	38	9.8	33	12.6	60	8.7	39	22.5	2.5	2.6	56.0	4.8
Junior	9.7	1.0	39	10.8	28	12.6	59	9.7	41	29.5	2.0	2.6	57.3	5.3
Senior	9.8	1.1	39	10.4	28	13.0	59	10.1	38	30.9	2.0	2.5	57.8	6.2
High School Varsity Basketball	9.2	0.9	46	9.2	32	14.2	63	9.1	44	33.3	2.3	2.6	55.0	5.4
Non-High School Varsity Basketball	9.7	1.0	37	9.6	30	12.6	59	9.4	40	29.4	2.3	2.5	57.2	5.4
Physical Education Major	8.9	0.7	48	10.6	37	12.6	67	8.4	51	34.2	3.1	2.4	53.2	4.7
Non-Physical Education Major	9.7	1.0	37	9.5	29	12.8	59	9.3	39	29.6	2.2	2.5	57.2	5.4

TABLE 2.—SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF RAW SCORES FOR THE SEVEN TEST ITEMS

Test Item	Comparisons							
	Freshmen Sophomore	Freshmen Junior	Freshmen Senior	Sophomore Junior	Sophomore Senior	Junior Senior	Major Nonmajor	Varsity Nonvarsity
40-Yard Speed Agility Run	2.39*	2.87*	3.80*	0.04	1.42	1.10	9.61*	6.36*
Basketball Throw for Distance	1.05	0.63	0.27	0.37	0.74	0.35	8.78*	10.90*
Sit-Ups	0.72	2.58*	2.87*	3.33*	3.65*	0.37	5.12*	1.76
Standing Broad Jump	0.31	0.25	0.79	0.57	1.12	0.55	8.28*	5.10*
Modified Chin	1.73	1.15	1.93	0.54	0.48	0.90	2.94*	1.52
Flexibility	0.65	1.47	1.34	0.76	0.63	0.15	3.24*	0.12
200-Yard Shuttle Run	0.26	2.47*	3.14*	2.31*	3.02*	0.91	7.21*	4.58*

*Significant at the .05 level of confidence.

4. The freshmen had a higher level of performance than the juniors or seniors in the 200-yard shuttle run. This difference was significant and increased for each additional year spent in college.

5. The sophomores had a higher level of performance in the 200-yard shuttle run than the juniors or seniors. This difference increased for each additional year spent in college.

6. The college girls who had played varsity basketball while in high school had a higher level of performance in the 40-yard speed and agility run, the basketball throw for distance, the standing broad jump, and in the 200-yard shuttle run than those college girls who had not played while in high school.

7. College women who were majoring in physical education were superior in performance of the entire battery to those who were nonmajors.

Conclusions

The basic hypothesis of this study was that there is no difference between college women in selected physical performance tests during their four years in college. The secondary hypotheses were that college women who had played high school varsity basketball do not differ in the level of performance of selected tests from those who had not played varsity ball and that college women majoring in physical education do not differ from nonmajors.

On the basis of the results from this study the following conclusions were drawn. The basic hypothesis can be rejected in that college women were found to differ significantly in such activities as the 40-yard speed and agility run, 200-yard shuttle run, and the number of sit-ups they can do. The longer the women had been in college the greater the decline in performance. The secondary hypotheses can also be rejected since college women who had played high school varsity basketball differed significantly from those who had not played in four of the seven test items (40-yard speed and agility run, basketball throw for distance, standing broad jump, and 200-yard shuttle run), and women physical education majors differed significantly from nonmajors in all seven of the test items.

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Appendix

Test Items and Administration

Item I: 40-Yard Speed and Agility Run

a. *Equipment:* Lane 10 ft. by 70 ft.; 3 Indian clubs placed 10 yd. apart; stop watch.
b. *Action:* The subject was instructed to stand at starting line to the right of the Indian club and on signal to run as fast as she could to the left of center club, to right of third club and around it, back to subject's left of center club, and to the right of begininng club.
c. *Score:* Time taken in tenths of seconds to complete the run.

Item II: Basketball Throw for Distance

a. *Equipment:* Lane 15 ft. by 90 ft.; beginning line about 9 ft. from wall; lines every 10 ft. beginning at 20 ft. and ending at 90 ft.; lines every 5 ft. between 30 ft. and 60 ft.; yellow Mystik tape was used for lines; numbers painted on 8-in. squares of linoleum were used for markers. They were leaned against gymnasium walls. If this was not possible, they were placed on the floor at the corresponding lines. Two basketballs; 5-ft. ruler.

b. *Action:* Subject was instructed to throw the ball as far as she could and in any manner she wished as long as she remained behind the starting line. Two tries were given and the better one was recorded.

c. *Score:* Recorded in feet.

Item III: Sit-ups (curls)

a. *Equipment:* Mats.

b. *Action:* Subject was instructed to lie flat on back, hands resting on the top of thighs. Assistant held feet of subject, who sat up and touched toes as many times as possible without stopping—50 was set as the maximum number. Movement had to be continuous. Elbows could not be used to push up nor were subjects allowed to grasp thighs and pull up.

c. *Score:* Number of times this movement was performed without stopping—50 was the maximum. One person supervised the curls. Subjects worked in pairs.

Item IV: Standing Broad Jump

a. *Equipment:* Take-off board 2 in. by 2 ft. by 5 ft. placed next to wall; mat 8 ft. by 2 ft., marked every 2 in. after the first 2 ft.

b. *Action:* Subject stood on end of board at beginning mark with feet together. She could flex knees and swing arms preparatory to jump. Subject jumped as far as possible—landing on both feet. Three tries were allowed.

c. *Score:* Number of inches jumped. Measured to nearest heel mark or where body touched floor in case of loss of balance. Recorded farthest jump of the three times.

Item V: Pull-ups (modified chins)

a. *Equipment:* Adjustable doorway gym bar; 45° angle box; mat.

b. *Action:* The subject stood behind bar so that it could be checked for correct height, grasped bar with forward grip, and slid feet forward (angle box determined 45° angle made by legs and floor) until the body and arms formed approximately a right angle when the body was held straight. The weight of the body rested on the heels. Subject pulled up as many times as possible. In executing the movement, the trunk was pulled up until the chin was even with the hands, then lowered body until the arms were straight. The body was held perfectly straight.

c. *Score:* Number of times this movement was performed without stopping.

Item VI: Flexibility

a. *Equipment:* Bench 12 in. by 18 in. by 9 in. with scale attached.

b. *Action:* Subject stood on the bench with her hands at sides and bent over reaching as far as possible without bending legs. Subject did this 3 times, holding point reached on last try for 3 sec.

c. *Score:* Recorded in inches the lowest point reached and held for 3 sec. Negative numbers were above the bench level and positive numbers were below the bench level.

Item VII: 200-Yard Shuttle Run

a. *Equipment:* Lane 12 ft. by 70 ft.; 2 Indian clubs placed 20 yds. apart; stop watch.

b. *Action:* Subject stood to right of starting club. On signal, "ready, go" she ran counterclockwise around the clubs, making 5 complete laps. Subject ran all the way if possible. If not, she walked the rest of the way.

c. *Score:* Time needed to complete 5 laps was recorded in tenths of seconds.

(Submitted 2/20/59)

Effect of Variations in Hand and Foot Spacing on Movement Time and on Force of Charge[1]

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Abstract

Twenty subjects were tested to determine if variations in hand and foot spacing affected force of shoulder impact and movement time. The relative effect of a rhythmical and a nonrhythmical count in giving the preparatory and starting signal on movement time and on force of shoulder impact was also studied.

The differences found in the force of shoulder impact scores of 40 varied stances were not significant at the 5 percent level of confidence. The differences, for the various stances, in the force of shoulder impact, with either a rhythmical or a nonrhythmical count as preparatory and starting signals, were not significant at the 5 percent level of confidence. Differences in speed of movement obtained from the varied stances were significant at the 1 percent level of confidence.

THE EFFECTIVE FORCE applied by an offensive lineman in football depends on certain basic body mechanics, but great differences of opinion as to the most suitable stance (initial, preparatory body position) have existed since the inception of the game (1, 2, 3, 5, 10, 11, 14, 16, 20). Numerous studies have been conducted to determine the optimum foot spacing for short distance sprinters. The conclusions reached by these various studies are not in agreement (3, 5, 6, 7).

The length of the fore-period (time interval between the preparatory stimulus and the stimulus to initiate overt action) seems to affect response time. Most experimental studies found the optimum fore-period to have a length of 1½ sec. to 2 sec. (10, 11, 13, 15, 16, 17).

Purposes of the Study

It was the purpose of this study to determine the effect of front-to-rear and lateral variations in foot spacing and variations in hand-to-toe anterior-posterior spacing on (1) movement time and (2) force of shoulder impact at the end of movement through a 36 in. horizontal distance. This study also attempted to determine the effect of a rhythmical and a nonrhythmical count in the starting signal on time of initiating and time of executing movement and on shoulder impact at the end of 36 in. of movement. In addition,

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[1] This study was made in partial fulfillment of the requirements for the degree of Doctor of Education in the College of Athletics and Physical Education, Pennsylvania State University, 1956, under the direction of John D. Lawther, Associate Dean.

as a part of the analysis, it was hoped that the relationship, if any, between these various factors could be found.

Definition of Terms

The concepts listed below are defined in terms of their meaning in this study.

Stance. Initial, preparatory body position taken by a football player, immediately prior to charging.

Fore-period. The time interval between the preparatory stimulus and the stimulus to initiate overt action.

Starting signal. Last vocal symbol in each verbal sequence of preparatory and starting sounds uttered for each subject by the investigator. In this experiment, this paricular symbol is the one with louder volume which activates a chronometer.

Rhythmical count. A verbal count in which the time interval between digits is constant.

Nonrhythmical count. A verbal count in which the time interval between digits is not constant.

Anticipatory time. Time interval between the last verbal symbol of the rhythmical preparatory and starting sequence as uttered by the examiner), and the initiation of movement by the subject.

Movement time. The time interval between the initiation of movement and the time of shoulder contact with the blocking dummy.

Reaction time. The time interval between the occurrence of the last verbal symbol in a nonrhythmical count and the initiation of movement of the subject.

Hand-to-toe anterior-posterior spacing. Distance between lines perpendicular to the sagittal plane of the subject which touch the foremost part of the front shoe and the foremost part of the hand contacting the ground.

Toe-to-toe front-to-rear spacing. Distance between lines perpendicular to the sagittal plane of the subject which touch the foremost part of the front shoe and the foremost part of the rear shoe.

Toe-to-toe lateral spacing. Distance between lines parallel to the sagittal plane of the subject which touch the inner borders of his respective shoes.

Force of shoulder impact. Force in pounds as measured by the apparatus especially constructed for use in this study.

Off-side. The initiation of forward movement by the subject before occurrence of the first syllable of the last verbal symbol of the preparatory and starting sounds.

Description of the Apparatus

The Lawowenometer, an apparatus especially constructed for this experiment, was used to measure the horizontal force of shoulder impact and the speed of movement of 20 members of the varsity football squad of Concord College, Athens, West Virginia.

The apparatus was constructed as shown in Figure I. The force of shoulder impact was measured by a dynamometer (D). This Dillon Model AN Dynamometer has a capacity of 500 lbs., and has a 10-in. dial which is divided into 2½ lb. divisions. For checking purposes, a red maximum hand is provided. This is pushed forward by the main indicator which is white. After tension is released, the white hand returns to zero leaving the red hand at peak point of load. The reading is taken, and the red hand is then returned to zero by means of a reset knob in the center of the dial glass.

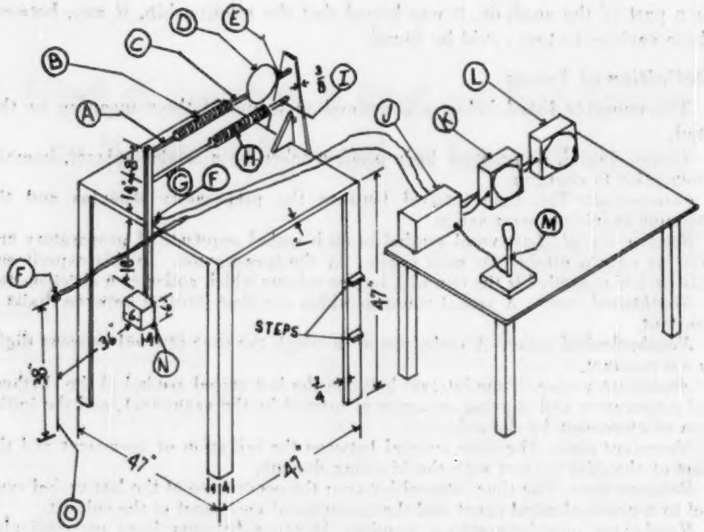

FIGURE I. Lawowenometer (scale ½" = 1').

The dynamometer (D) is fastened on one end to a bracket, located on the back side of the Lawowenometer, and on the other end to a coil spring (B) which is attached to the lever which supports dummy (N). This attachment is 8 in. lower than that of coil spring (B).

As a means of measuring speed of movement, an electric chronometer (L) was placed in circuit with microswitches F_1 and F_2 and an amplifier and control relays (J). This Model S-1 Chronometer, manufactured by the Standard Electric Time Company, has a fast hand speed of 1 RPS, totalizes to 60 sec., and is graduated in one-hundredth of a second. It has an accuracy of .01 second per operation with an a-c clutch and is reset manually. The Model SW-1 Chronometer (K) has the same characteristics except that it resets electrically. It was placed in circuit with a microphone (M), amplifier and control relays (J), and micro-switch (F_2).

Another part of the apparatus is shown in Figure II. A loud voice peak is amplified through V^1 and V^2 vacuum tubes, which energies voice control relay[1]. Voice control relay[1] energizes L^1 set of coils on latching relay[2] which completes the electrical circuit for chronometer #1. Micro-switch (F_1) completes the electrical circuit to energize (L^1) set of coils on latching relay[3] which completes the electrical circuit for chronometer #2. Micro-switch (F_2) energizes coils (L^2) on latching relay[2] and on latching relay[3], which breaks the circuit and stops chronometers one and two.

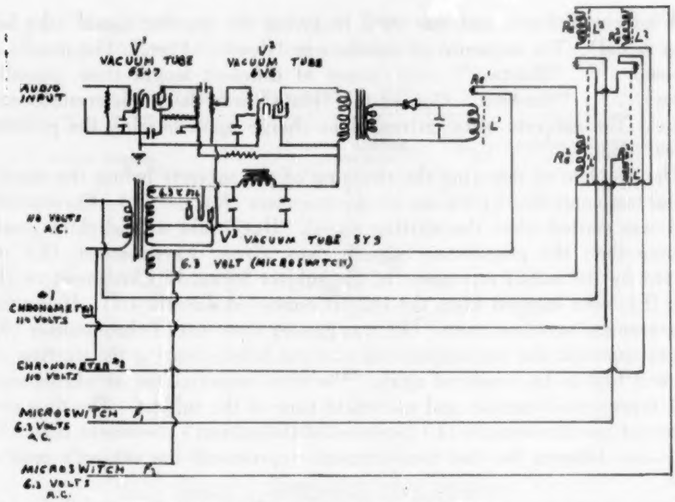

FIGURE II. Amplifier and control relays.

An audio frequency is received by the microphone (M), and is transmitted to the amplifier and control relays. Here the frequency is amplified sufficiently to energize L^1 which closes Re^1 (voice controlled relay), which activates Re^2 (latching type relay), which starts chronometer (K). Forward movement of micro-switch F_1 trip (O), closes micro-switch F_1, activating Chronometer (L). Contact with the dummy (N), causes micro-switch F_2, which is mounted on the dummy lever at its fulcrum, to be opened, thereby breaking the electrical circuit and stopping chronometers (K) and (L). The force with which the dummy (N) is contacted is measured by dynamometer (D).

Twenty-nine subjects were used to test the reliability of the Lawowanometer. They observed a demonstration of how to assume the starting position, so that the right hand would be in contact with the ground and the right shoulder would be in contact with micro-switch F_1 trip (O). This trip, when moved forward, closes micro-switch (F_1) making the circuit and activating chronometer (L). The front-to-rear and lateral variations in foot spacing and the variation in hand-to-toe anterior-posterior spacing were to be the same as those used by the subject assuming his normal stance. Dummy (N) would be contacted with the right shoulder and this contact would cause micro-switch (F_2) to be opened, breaking the electrical circuit and stopping chronometers (K) and (L). The subjects were instructed to charge through the dummy rather than "lunge at it."

A nonrhythmical count was used in giving the starting signal (the ball-snap signal). The sequence of signals was "Ready," "Set," "Hut-two," . . . (pause) . . . "Hut-two," . . . (pause of different length than preceding pause). . . . "Hut-two." One of the "Hut's" was the predetermined snap signal. The subjects were instructed to charge upon hearing the predetermined "Hut."

The problem of detecting the charging of the subjects before the starting signal was controlled by the use of chronometers (K) and (L). Chronometer (K) was started when the starting signal, "Hut," said with slightly greater volume than the preparatory signals, was given. Chronometer (L) was started by the initial movement of the subject forward. Chronometers (K) and (L) were stopped when the subject contacted dummy (N). If the time measurement on chronometer (L) was greater than that of chronometer (K), it was apparent that the subject had charged before hearing the starting signal and had to be measured again. The time measurement on chronometer (K) represented reaction and movement time of the subject. The time measurement on chronometer (L) represented the subject's movement time. The difference between the two measurements represented the subject's reaction time.

Each subject was measured four times in order to test the reliability of the Lawowenometer. The reliability of the force-measuring device was determined by selecting the two greatest forces recorded for each subjct and correlating them. The application of the Pearson product-moment coefficient of correlation formula to the greatest forces recorded for each subject produced a coefficient of reliability of .96. To determine the reliability of the reaction-movement time measuring device, the two minimum times for each subject, as measured by chronometer (K), were selected and the formula for the Pearson product-moment method of correlation was applied. A coefficient of reliability of .87 was obtained. To determine the reliability of the movement time device, the two minimum times for each subject, as measured by chronometed (L), were selected and the formula for the Pearson product-moment method of correlation was applied. A coefficient of reliability of .88 was obtained.

Procedure

The 20 subjects used in this experiment were divided into four groups, five to a group. The 40 different stances, from which the force of impact and speed of movement of each subject were measured, were divided into four groups, ten to a group. So that no definite sequence of stances would occur, which might conceivably influence the variables measured, a system of rotation of subjects and stances was utilized.

The various stances from which the subjects were measured are as described in Tables 1 and 2. Stances 1 through 12 are parallel type stances with variations in the toe-to-toe lateral spacing and hand-to-toe anterior-posterior spacing but no variations in the toe-to-toe front to rear spacing.

The parallel type stances are found in Table 1. Stances 13 through 39 are sprinter type stances and are found in Table 2.

TABLE 1.—PARALLEL TYPE STANCES

Stance Number	Toe-to-Toe Lateral Spacing (*in inches*)	Hand-to-toe Anterior-Posterior Spacing (*in inches*)
1	15	18
2	18	18
3	21	18
4	24	18
5	15	21
6	15	24
7	18	21
8	18	24
9	21	21
10	21	24
11	24	21
12	24	24

TABLE 2.—SPRINTER TYPE STANCES

Stance Number	Toe-to-toe Lateral Spacing (*in inches*)	Toe-to-toe Front-to-rear Spacing (*in inches*)	Hand-to-toe Anterior-Posterior Spacing (*in inches*)
13	12	8	18
14	18	8	18
15	24	8	18
16	12	16	18
17	12	24	18
18	18	16	18
19	18	24	18
20	24	24	18
21	24	24	18
22	12	8	21
23	12	8	24
24	18	8	21
25	18	8	24
26	24	8	21
27	24	8	24
28	12	16	21
29	12	16	24
30	18	16	21
31	18	16	24
32	24	16	21
33	24	16	24
34	12	24	21
35	12	24	24
36	18	24	21
37	18	24	24
38	24	24	21
39	24	24	24
40	(That stance normally used by the subject)		

Each subject was tested individually under the following conditions:

1. All subjects were thoroughly oriented as to the experiment and especially as to the apparatus that was employed.

2. There was a short warm-up period preceding each day's test so that the subjects could prepare themselves for the test. Approximately 15 min. were spent taking calisthenics and running.

3. Each subject was given stance boards of the two stances from which he was to be tested on that particular day. Time was allowed for the subjects to practice starting from each of these stances.

4. The subject assumed the stance from which he was to be measured by placing his feet in the stance board. The right hand was placed in contact with the ground at the forward edge of the stance board. The center of gravity of the body was pitched forward until the right shoulder was in contact with micro-switch (F_1) trip (O) (Figure I). This placed the subject in a starting position that assured his right shoulder being 36 inches from the dummy (N). The stance board was folded in the center and removed before the subject charged.

5. Each subject was measured four times from each stance. For two of these measurements, a rhythmical count was used to give the preparatory and starting signals, and for two, a nonrhythmical count was used. The sequence of the rhythmical signals was, "Ready," "Set," "One, two, three." Three was always the last vocal symbol given in the rhythmical sequence. This last symbol had greater volume and started chronometer (K) (the ball-snap signal). The investigator attempted to keep the cadence constant so that a foreperiod of 1.5 to 2 sec. would be approximated. The sequence of the nonrhythmical signals was "Ready," "Set," "Hut-two" . . . (pause) . . . "Hut-two" . . . (pause of different length than preceding pause). . . . "Hut-two." The subject was instructed before each trial as to which "Hut" was to be the starting signal. The rhythmical and nonrhythmical counts were alternated in order to prevent establishing a set pattern or sequence which might possibly have affected the measurements being taken.

6. The investigator had three assistants who helped during the testing procedure. One assistant was in charge of placing the subjects in the correct stance and removing the stance board before each test. Another assistant took all force of impact readings from the dynamometer (D). The third assistant took all readings from chronometers (K) and (L) and recorded these readings and the force of impact reading from the dynamometer. On all measurements where the subject was detected as being off-side (the reading on chronometer (L) being greater than the reading on chronometer (K), all scores for that particular trial were discarded and the subject was remeasured.

Analyses of Data

An analysis of variance was calculated on the data in order to determine the effect of front-to-rear and lateral variations in foot spacing, and variations

in hand-to-toe anterior-posterior spacing, on force of shoulder impact at the end of movement through a 36-in. horizontal distance. This showed that the differences in the forces obtained from the 40 varied stances were not significant at the 5 percent level of confidence (F = 1.216). The analysis further showed that the difference in the force of shoulder impact measurements, obtained when using a rhythmical count in giving the preparatory and starting signals, was not significant at the 5 percent level of confidence (F = 1.377). The interaction of stance and rhythm did not produce a significant difference in the force of shoulder impact measurements (F = 0.052). Table 3 presents a summary of the analysis of variance of force of shoulder impact.

TABLE 3.—ANALYSIS OF VARIANCE OF FORCE OF SHOULDER IMPACT SUMMARY

Sources of Variance	Degrees of Freedom	Sum of Squares	Means of Squares
Rhythm	1	1,510.08	1,510.08
Stance	39	52,032.00	1,334.15
Interaction	39	2,251.72	57.73
Within	1,520	1,666,577.20	1,096.43
Total	1,599	1,722,371.00	

$$F_{39,1520} = \frac{S^2_s}{S^2_w} = \frac{1334.15}{1096.43} = 1.216$$ Not significant at the 5 percent level of confidence.

$$F_{1,1520} = \frac{S^2_r}{S^2_w} = \frac{1510.08}{1096.43} = 1.377$$ Not significant at the 5 percent level of confidence.

$$F_{39,1520} = \frac{S^2_{rxs}}{S^2_w} = \frac{57.73}{1096.43} = 0.052$$ Not significant at the 5 percent level of confidence.

An analysis of variance was applied to the data in order to determine the effect of front-to-rear and lateral variations in foot spacing, and variations in hand-to-toe anterior-posterior spacing, on speed of movement through a 36-in. horizontal distance. This showed that the differences in the movement-time measurements, obtained from the 40 varied stances, were significant at the 1 percent level of confidence (F = 12.31). The analysis further showed that the difference obtained in the speed of movement when using a rhythmical count and a nonrhythmical count in giving the preparatory and starting signals was not significant at the 5 percent level of confidence (F = .375). The interaction of stance and rhythm produced significant differences in the speed of movement measurements (F = 1.81). Table 4 presents a summary of the analysis of variance in speed of movement.

The means of the movement-time scores and the means of the reaction-time scores (as measured by the Lawowenometer when a nonrhythmical count was used in giving the preparatory and starting signals) of the 20 subjects, who were measured from 40 varied stances, were correlated in order to determine their relationship or association. This correlation (r = .075) was not significant at the 5 percent level of confidence. This indicated that the reaction time function and the movement time function are independent and unrelated.

TABLE 4.—ANALYSIS OF VARIANCE IN SPEED OF MOVEMENT SUMMARY

Sources of Variance	Degree of Freedom	Sums of Squares	Mean of Squares
Rhythm	1	.0006	.0006
Stance	39	.7691	.0197
Interaction	39	.1136	.0029
Within	1520	2.4494	.0016
Total	1599		

$$F_{1,1520} = \frac{S^2_r}{S^2_w} = \frac{.0006}{.0016} = .375$$ Not significant at the 5 percent level of confidence.

$$F_{39,1520} = \frac{S^2_s}{S^2_w} = \frac{.0197}{.0016} = 12.31$$ Significant at the 1 percent level of confidence.

$$F_{39,1520} = S^2_{rxs} = \frac{.0029}{.0016} = 1.81$$ Significant at the 1 percent level of confidence.

The means of the anticipatory-time scores and the means of the movement-time scores (obtained when a rhythmical count was used to give the preparatory and starting signals) for the 20 subjects were subjected to the Pearson product-moment method of correlation in order to determine their relationship or association. The anticipatory-time scores represent a response to a different kind of stimulus from that of the nonrhythmical signal. With the rhythmical count, it is possible to initiate movement using the mental approximation of the rhythmical time interval as the stimulus instead of the so-called "starting signal." This correlation between anticipatory time and movement time ($r = .134$) was not significant at the 5 percent level of confidence. This indicated that the anticipatory time function and the movement time function were independent and unrelated.

The means of the anticipatory-time scores (obtained when a rhythmical count was used in giving the preparatory and starting signals) and the means of the reaction-time scores (obtained when a nonrhythmical count was used in giving the preparatory and starting signals) were correlated. This correlation ($r = .342$) was not significant at the 5 percent level of confidence. This indicated that the anticipatory-time function and the reaction-time function are independent and unrelated.

There were 3323 trials measured. Of these trials, 123 (approximately 4%) represent off-sides that were committed during the experiment; 77 percent (95) of the off-sides occurred when a rhythmical count was used in giving the preparatory and starting signals, and 23 percent (28) occurred when a nonrhythmical count was used. Of course, some of these may have represented so few thousandths of a second that they would go undetected in actual game situations.

The anticipatory time plus movement time scores (obtained when a rhythmical count was used in giving the preparatory and starting signals) and the

reaction time plus movement time scores (obtained when a nonrhythmical count was used in giving the preparatory and starting signals) were analyzed in order to determine which method of calling signals resulted in the shortest interval between last verbal symbol and completion of movement. The mean total time for the 20 subjects when a rhythmical count was used was .562 seconds. The range was from .477 seconds to .670 seconds. The mean total time for the 20 subjects when a nonrhythmical count was used was .714 seconds. The range was from .652 seconds to .810 seconds. The difference between the two means is significant at the 1 percent level of confidence ($t = 12.67$).

Summary and Conclusions

The findings of the investigation are summarized here:

1. The differences in the forces obtained from the 40 varied stances were not significant at the 5 percent level of confidence ($F = 1.216$).
2. Neither rhythmical nor nonrhythmical preparatory and starting signals produced differences in the forces of shoulder impact that were significant ($F = 1.377$).
3. The interaction of stance and rhythm did not produce a significant difference in the force of shoulder impact measurements ($F = 0.052$).
4. The differences in the movement-time measurements, obtained from 40 varied stances, were significant at the 1 percent level of confidence. ($F = 12.31$).
5. Neither rhythmical nor nonrhythmical preparatory and starting signals produced differences in the speed of movement measurements that were significant ($F = .375$).
6. The interaction of stance and rhythm produced significant differences in the speed of movement measurements ($F = 1.81$).
7. The coefficient of correlation between force of shoulder impact and movement time per stance was —.95. (This high negative correlation is due to the fact that a lower numerical score in a timed event represents a better performance.)
8. The coefficient of correlation between force of shoulder impact and weight per individual was .73.
9. The coefficient of correlation between reaction time and movement time per individual was .075.
10. The coefficient of correlation between anticipatory time and movement time per individual was .134.
11. The coefficient of correlation between anticipatory time and reaction time per individual was .342.
12. The use of a rhythmical count in giving the preparatory and starting signals resulted in more off-sides.
13. The length of legs affects optimum foot and hand spacing when force of shoulder impact is the determining criterion.

14. The length of legs did not seem to affect optimum hand and foot spacing when speed of movement is the determining criterion.

15. Time from last verbal symbol to end of movement was shortest when a rhythmical count was used in giving the preparatory and starting signals (mean = .562 seconds).

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Bruce Physical Fitness Index as a Predictor of Performance in Trained Distance Runners

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Abstract

The Bruce Physical Fitness Index was administered to 11 high school cross-country runners in an attempt to determine the relationship between scores and performance. Various anthropometric and physiologic tests also were administered. The results indicate that the BPFI is not a useful predictor of performance. Performance and measures of body size are negatively correlated. The efficiency of the BPFI appears to be reduced by the inclusion of the "average respiratory efficiency," which correlates highly with measures of body size.

THE BRUCE Physical Fitness Index has been proposed as "an improvement of the formula employed by the Harvard Fatigue Laboratory for evaluating performance in athletes at exhausting work loads" (3). The formula for this index is

$$\text{Physical Fitness Index} = \frac{E \cdot R \cdot K}{C}$$

E = duration of exercise in minutes
R = "average respiratory efficiency" (difference in oxygen concentration between inspired and expired air)
K = 100
C = cumulative heart rate for the first three minutes of recovery

The exercise consists of walking on a motor driven treadmill with a 10 percent grade at the rate of 1.7 miles per hour for a maximum of ten minutes.

In a previous study it was shown that scores for the Harvard Step Test Recovery Index are not significantly related to scores for the Bruce Physical Fitness Index ($r = .236$) (8). This suggests either that the tests are not measuring identical items to the same extent or that different items are measured by each; it raises the question of whether the Bruce Physical Fitness Index predicts performance better than does the Harvard Step Test Recovery Index. It has been known for some time that the Harvard Step Test Recovery Index does not correlate well with times in the mile run (5). It was the purpose of this investigation to determine the relationship between scores in the Bruce Physical Fitness Index and times in distance running, and between performance and anthropometric and physiologic measurements.

TABLE I.—INTERCORRELATIONS OF PHYSIOLOGIC AND ANTHROPOMETRIC DATA

	Cross-Country Performance	Bruce PFI	Resting Heart Rate (1 min.)	Postexercise Heart Count (3 min.)	"Average Respiratory Efficiency"	Ponderal Index	Reciprocal Ponderal Index	Body Surface Area	Oxygen Volume per m² BSA	Lean Body Mass	Height	Weight
Cross-Country Performance	—	0.47	0.32	0.52	—0.25	—0.48	0.37	—0.12	—0.36	—0.18	0.05	—0.15
Bruce PFI	0.47	—	—0.60	—0.74[a]	0.28	0.37	—0.29	0.29	0.54	0.36	0.21	0.31
Resting Heart Rate (1 min.)	0.32	—0.60	—	0.90[a]	0.44	—0.15	0.13	0.40	—0.44	0.33	0.46	0.35
Postexercise Heart Count (3 min.)	0.52	—0.74	0.90	—	0.09	—0.14	0.12	0.33	—0.36	0.55	0.41	0.19
"Av. Respiratory Efficiency"	—0.25	0.28	0.44	0.09	—	0.73[a]	—0.58	0.84[a]	0.17	0.84[a]	0.69	0.91[a]
Ponderal Index	—0.48	0.37	—0.15	—0.14	0.73	—		0.36	0.44	0.44		
Reciprocal Ponderal Index	0.37	—0.29	0.13	0.12	—0.58		—	—0.26	—0.35	—0.33		
Body Surface Area	—0.12	0.29	0.40	0.33	0.84	0.36	—0.26	—		0.16		
Oxygen Volume per m² BSA	—0.36	0.54	—0.44	—0.36	0.17	0.44	—0.35		—	0.13	—0.08	0.07
Lean Body Mass	—0.18	0.36	0.33	0.55	0.84	0.44	—0.33	0.16	0.13	—		
Height	0.05	0.21	0.46	0.41	0.69				—0.08		—	0.64
Weight	—0.15	0.31	0.35	0.19	0.91				0.07		0.64	—

[a] r = 0.71 is statistically significant

Procedure

Eleven runners from the cross-country team of a large high school volunteered to serve as subjects.[1] The team was just finishing the season, and each man's most recent dual meet performance was a matter of record. The Bruce Physical Fitness Index for each subject was determined by the use of an Arnold O. Beckman Model C Oxygen Analyzer and a Burdick EK-2 Electrocardiograph. Simultaneously each subject's total oxygen consumption during the test was recorded by means of an Arnold O. Beckman Model F-3 Oxygen Analyzer. The lean body mass was calculated according to the Rathbun-Pace (9) and Cowgill (4) formulas.

Results

The intercorrelations of the selected anthropometric and physiologic measurements recorded during this investigation are presented in Table I. No correlation coefficient was considered statistically significant unless the chance occurrence of such a statistic was 1 percent or less.

Discussion

The mean score of 32 is considerably above the 26 considered characteristic of athletes on the Bruce continuum, and there is no apparent consistency between physical fitness scores and performance. The man with the best performance (9′56″) made the highest score (40) on the Bruce Physical Fitness Index, but the man with the poorest performance (11′39″) made the second highest score (37).

When the performance of all subjects was correlated with their Bruce Physical Fitness Index it was found that $r = .47$, which was not statistically significant. The correlation between performance and the total heart count for the first three minutes immediately following exercise was $r = .52$, which was likewise not significant. This confirms Taylor's dictum that "recovery of heart rate during the first three minutes after the submaximal walk is likewise unpromising as a reliable measure of fitness as determined by time run" (11). The fact that the "average respiratory efficiency" contributed little if anything to the predictive value of the Index is consistent with the finding of Balke and Ware (1) that the amount of oxygen consumed per unit of body mass at a given work load is an impractical criterion of an individual's work efficiency.

Confirmation of the above was received from two other findings: (1) the correlation between the "average respiratory efficiency" and the time for the run was $r = -0.25$; (2) positive correlations at the 1 percent level of confidence were obtained between the "average respiratory efficiency" and

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[1] The writers are indebted to Elmer J. Erickson, principal of South Pasadena High School, Coach James Brownfield, and to the volunteers from the cross-country team for their cooperation in this study.

various measures of body size, such as the ponderal index ($r = .73$), body surface area ($r = .84$), lean body mass ($r = .84$), and weight ($r = .91$), each of which had a negative correlation with performance.

An examination of these measures demonstrated that this finding could not be attributed to the fact that the cross-country runners were atypical in these respects. For example, the mean ponderal index for the subjects was 223. Data collected by Ray (10) during a study of California high school male students reveal a mean ponderal index of 231 for unselected students of the age most closely approximating that of the subjects in the present study. Other anthropometric data are also unexceptional. For one subject, the calculated specific gravity exceeded the limits encompassed by the Rathbun-Pace formula. However, similar observations have been reported in a study of Boy Scouts and were attributed to the fact that adolescents tend to have more extracellular fluid than do adults (4).

In view of the aforementioned findings it may be concluded that the high positive correlation between "average respiratory efficiency" and measures of body size is not peculiar to cross-country runners. That the correlation between "average respiratory efficiency" and weight is greater than that between "average respiratory efficiency" and lean body mass indicated the former is more closely related to the total protoplasmic mass than it is to what Behnke (2) denotes the "active protoplasmic mass," that is, the body free of metabolically inert depot fat but with adipose tissue protoplasm.

It will be noted that there was no significant correlation ($r = .17$) between "average respiratory efficiency" and the mean volume of oxygen consumed per minute per square meter of body surface area, and that the latter measure had a negative correlation ($r = -.36$) with performance. These interrelationships suggest that the ability to make efficient use of the oxygen present is more important in preventing anoxia at the tissue level than is the ability to exchange large quantities of this gas. If such a hypothesis is correct, it may explain why earlier studies of marathon runners (6) and wrestlers (7) have shown that these athletes do not possess unusual vital capacities.

Summary and Conclusions

The Bruce Physical Fitness Index test was administered to 11 high school cross-country runners, and the individual scores were correlated with performance and various anthropometric and physiologic measurements. On the basis of the analyses of the data, the following statements appear justified:

1. The Bruce Physical Fitness Index is not a useful predictor of cross-country run time.

2. The predictive value of the test appears to be reduced by the fact that one of its individual components, "average respiratory efficiency," correlates highly with measures of body size, which are themselves negatively correlated with performance.

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An Account of Ruth St. Denis in Europe, 1906-1909[1]

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Abstract

A complete account of the European success of the American dancer, Ruth St. Denis, has never been written. This article, prepared from original and heretofore untranslated manuscripts, gives a complete account of St. Denis' personal triumph in Europe during the years 1906-1909. St. Denis' spectacular personal success in Europe is shown to have had three important historical results: (1) it helped complete the renaissance of dance started by Loïe Fuller, Isadora Duncan, and Maud Allan, (2) it prepared eager and enormous audiences for whole evenings of pure dance, (3) it foreshadowed the vivid ballet productions of Diaghilev.

WHENEVER AN ACCOUNT of the career of the American dancer Ruth St. Denis is given in dance histories, a few vague lines are invariably included about her fabulous stage success as a dancer in Europe early in this century. This was at the beginning of her long career, specifically during the years 1906-1909. Walter Terry sums this period up in one paragraph in his book, *Dance in America:*

> Following her first concerts, Ruth St. Denis left for Europe and triumph. London liked her; Paris, after an episode involving an imposter calling herself Radha, adored her; and in Germany her triumph was complete. The critics viewed her works seriously, and articles concerning her divulged the philosophical and spiritual aspects of her dancing. In short, she was treated as an artist. She remained in Germany for almost two years . . . (16).

John Martin states matter-of-factly in his book *The Dance: "It* [*Radha,* St. Denis' first solo] won a sensational artistic success . . . in Europe" (8), Ruth St. Denis herself, in her 1939 autobiography *An Unfinished Life,* devotes many pages to the years she danced in Europe (14). However, as might be expected, this gives a highly romanticized account of her personal life rather than objective presentation of her professional appearances. Nowhere is there a complete account of St. Denis' activities at this important point in her career. Just what sort of an impression as a dancer did Ruth St. Denis make in Europe? Are her extravagant claims of high success there sound ones? Was she as influential or as popular as her American contemporaries, Loïe

[1]This article is an abstract of a dissertation presented in partial fulfillment of requirements for the degree of Doctor of Philosophy in American History at the Claremont Graduate School, Claremont, California, June, 1959.

Fuller, Maud Allan, and Isadora Duncan, who were also appearing in Europe around the turn of the century and were finding success? Just what *was* the success of Ruth St. Denis in Europe during the years 1906-1909? The following article seeks to answer that question.

During her early youth, St. Denis had appeared on the American stage as both actress and dancer in small parts of large productions, two of which were produced by the impresario, David Belasco. She became briefly successful as a solo dancer on Broadway in New York during the spring of 1906. On March 22 of that year, she presented a matinee performance of her dances *Incense, The Cobras,* and *Radha* before the society world of New York at the Hudson Theatre. Before this, she had appeared for a few weeks in vaudeville at the high paying Proctor's Twenty-third Street Theatre, and she had been presented by the Hudson Theatre producer, Henry B. Harris, in a series of matinees at his theatre. For a brief time (about three months) she was a flash success in America.

In May, the New York season was drawing to a close, so Harris arranged with Charles Frohman to present Radha (St. Denis used this briefly as a stage name) in three matinees at the Adlwych Theatre in London in July, 1906. Excitedly, she and her entire family set sail for London, after a final American performance in Boston in the Fenway Court Palace of Mrs. Jack Gardner. Up to this point, Ruth St. Denis was not a name of great importance in the entertainment world.

Nor did she increase her reputation a great deal in London. The Aldwych matinees were reasonably successful, but more important—as well as remunerative—were the society appearances she made in London. Armed with a letter of introduction to the Duchess of Manchester, who introduced her to Sir Lawrence Alma-Tadema, she flitted, like Isadora before her, in and out of the salons and studios and gardens of Edwardian England, appearing before the King himself on one occasion. She became known there as another American dancer, along with Duncan and Fuller, but otherwise the brief two months spent in London in the summer of 1906 were not distinguished.

Agents visited her performances at the Aldwych, but she finished her contract there with nothing settled for the future. She finally hired an agent of her own who obtained for her a month's contract at the Marigny Theatre in Paris, beginning on the first of September. In the meantime, a Paris impresario, whose ridiculously low offer to appear at the Olympia St. Denis had refused, sponsored a substitute Radha at his house, in imitation of St. Denis' best known dance.

The appearance of an imitator was a great blow to St. Denis. Stunned by the fraud, she tried to get legal help, unavailable in any country for stolen acts in those days. She had no recourse but to hope the fraud would be unsuccessful. Amazingly, as in any storybook, the heroine won out. The fraudulent Radha was soon hissed off the Olympia stage. The genuine Radha made an instantaneous hit at the Marigny. Again she was a flash success for

a few months. This was indicated by the fact that the populace mobbed her outside the theatre and the Rothschilds visited her backstage.

Although she did not like the compromising atmosphere of the Marigny Theatre, she finished her September contract there and was offered an extension until October 11, 1906. She made friends in Paris and was sketched by Rodin, but she never felt at home there. Gladly she signed a Berlin contract for the Komische Oper and left for Germany and, she hoped, greater appreciation. As yet, St. Denis was not much more than a touring American dancer.

St. Denis arrived in Berlin with a few scattered bookings at the Komische Oper. She was introduced to German audiences in the second act of Delibes' opera *Lakmé*, playing at the Komische Oper during the month of October. She performed her cobra dance as part of the opera's riotous second scene set in an Indian market place and added more color and life to an already full stage. A dark curtain was stretched between two poles in the middle of the stage, and before it the snakes coiled and struck, after which the opera went on as before. She was only one part of the whole opera.

Not content with such a billing, she arranged a matinee featuring her own three dances on October 27. She was well received. Programed with two short operas, she played an evening performance on the first of November. Then the artists of Berlin took her up. They arranged another matinee in the suburb Charlottenburg at the Theatre des Westerns on November 18, when, whisked like a true celebrity through a cheering crowd, she was afterwards carried off to a special luncheon at the Automobile Club. Artists like Hauptman, Von Hofmannstahl, Wedekind, Kessler, Richter, and Hofmann feted her. This was high triumph.

It was with somewhat of a shock, then, that it was learned that she had agreed to appear at the Wintergarten, a variety house in Berlin. It was one of the three *spezialitätentheatre* for which Berlin was famous at this time. They featured vaudeville acts for all kinds of society. There, the military, rich civilians, and high society rubbed elbows with tourists, gypsies, and coquettes. And in the cheap seats on the far sides sat the patrons who, by their mass, determined the type of show on the boards. Ernst Walter Trojan, critic of *Der Mensch*, characterized the members of this audience as a special kind of Philistine, one that gave the German *spezialitätentheatre* its flavor:

> It [The Wintergarten] wants only to amuse. And for that purpose, the Philistine needs cigar smoke and beer. Between a deep draught from a glass and a devotional pull on the nicotine stalk, he allows himself to be taken in by neck-breaking acrobat tricks and belly-tickling wits. At the same time he must chatter, must call after the waiter, and everytime that it pleases him, he must be able to go into the toilet: in short, he must be comfortable (9).

It was this audience who insisted that the acts consist of some kind of sensationalism, some touch of erotic sensualism. And always it demanded the new, the unprecedented, Trojan lamented.

St. Denis' dances obviously filled the bill. Conjecturing as to why she consented to appear in such a place, Trojan closed with the succinct observation, "The distinguished artist can also use money, and the Wintergarten pays"—15 thousand francs a month (9). The Komische Oper sued her on the grounds that she had used the opera's contract as a means of advertisement.

How long St. Denis stayed at the Wintergarten is not known, but this appearance was only the first of many in such *spezialitätentheatre* all over Europe. In Prague, twice in Vienna, in Düsseldorf, Hamburg, Brussels, Dresden, Budapest, Nürnberg, Graz, and Monte Carlo, with more returns to Berlin, St. Denis was the attraction which made for sold-out houses. She appeared on the same program with eccentrics, comedians, quartets, dogs, jugglers, contortionists, acrobats, and tableaus—all the acts which characterized *variété* in its heyday, whether in Europe or America.

The incongruity of the intentions of her act and the audience to which it appealed has bothered the intellectual St. Denis all through the years. Practically, however, there was no other way to support herself, she being Ruth St. Denis. Duncan during the same years never deigned to appear in a *variété,* but she supported herself in ways St. Denis thought equally shocking—by finding a series of rich patrons. Loïe Fuller went from American burlesque to the Parisian Folies Bergere, and her particular contribution to art became no less important in history. It was the lot of Ruth St. Denis to make her fame and fortune in vaudeville houses, somehow never losing her personal innocence through decades of music hall appearances. Thus she made her contribution to dance history in her way.

There is no doubt that St. Denis as a dancer appealed to vaudeville audiences. Another German writer, in the *Frankfurter Zeitung,* pondered on the type of audience to which she was exposed. For example, just as he would become absorbed in "the 'Three Gordons' readying themselves for a neckbreaking header," a phlegmatic dame behind him would be talking of something else. "That is typical," he wrote. "That happens so often in *variété* in the city that one begins to believe that one has always the same people here, and what one hears will always be the same." These persons' reactions to a number on a program could never be counted on, he continued. Of the simplest numbers, the dame behind him would whisper loudly:

> (She speaks always in *variété* German): "What's that?" And even that she says that, that belongs also. One must always take into consideration the stupidity of the public. The program hinges on this. The one who does not understand the Knockabouts [a comedy team of singers] will admire the magicians or the trained monkeys (4).

Then as to St. Denis:

> Serious numbers are also included. Even Ruth St. Denis dances now under the firmament of half-art . . . but certainly if the phlegmatic woman says that such an act does not belong here, she is not wrong. *Variété* does not always degrade the artist, but it depreciates the personal performance. It makes us lazy for applause. The graceful dance poet intensifies her performance to the spectacular, in a kind of stylized fakir-enthusiasm, while the man with the phlegmatic dame lights his third cigar . . . (4).

To such an audience St. Denis played for years. And it was puzzling to some critics because she didn't appeal in the usual erotic manner of a woman. True, she danced almost nude, with a covering only around the breast and loins, but she was large and almost too slender. "One seeks in vain on her the broad full hips of the child-bearing woman," Trojan wrote. Only the thigh was feminine. But her ability to hypnotize the general crowd could not be denied. As soon as she stepped out,

> Every lascivious thought flees shy into the farthest corner. One wishes to preserve the calm quiet one's self, but these sedate steps of high dedication, the arms swinging in highly exalted curves, this Sphinx face of unapproachableness, with the soft-socketed eyes, have in an instance freed our soul from the clutches of everyday life and carried them to cleaner and more beautiful life form. (9).

Throughout 1907, St. Denis made the rounds of the European variety houses. Her brother Buzz had taken over the duties of stage manager for a company which had grown, by the time she reached Vienna in 1908, to include a conductor, Walter Meyrowitz. The rest of her family had returned to America, so St. Denis and brother were the combination who played the German cities for two years. St. Denis herself had blossomed into "a Gibson-girl with a high piled tonsure" (12). Particularly noteworthy was the fact that her hair had turned white prematurely. Even at thirty, she was reported as having a "peculiar charm" because of "a grey streak in her rich white hair" (1).

This "thoroughbred American" (1) made many friends among artists and musicians and frequented the circles of art-minded aristocrats. Most nostalgic were her memories of long talks and walks with Hugo von Hofmannstahl. One auspicious occasion was that in which St. Denis as model and Von Hofmannstahl as narrator combined with Mariano Fortuny in a demonstration of the latter's veils inspired by the bas-reliefs excavated at Knossos in Crete. Before an audience selected from German society, St. Denis modeled the transparent silken webs over a flowing linen dress of neutral white. One reviewer described St. Denis as follows:

> Ruth appeared, and in the undulating play of her artistic limbs, and in low dips revolving in unending melodies, and in soaring rhythmic movement that flowed from the hips like a magnetic fluid, all the infinite possibilities of those veils became vividly alive (12).

Here is a picture of the naturally graceful young St. Denis during the years of her greatest triumph.

Although St. Denis made her money in the music halls, her keenest appreciation came from the artists and aristocrats. Von Hofmannstahl had written a long review entitled "Die unvergleichliche Tänzerin" ("The Incomparable Dancer") after her first Berlin press performance in October, 1906. He was fascinated by her unique combination of voluptuousness and chastity. Similarly ecstatic were the reviews in December 1907, when she gave a closed press performance to the elite of Budapest—state secretaries, doctors, uni-

versity professors, city councillors, editors, the principal of the Hungarian National Museum, the ballet master of the Hungarian Opera, and the cream of Hungarian critics. Something happened, wrote "Ursus" in *The Reflector* on December 4,

> When the curtain fell on the statue-like body of St. Denis at the end, the audience at the premiere stayed in its seat as one person. I emphasize, they were those people in Budapest, those writers and performing artists, and other artists, for whom nothing is really new, who, any other time in the middle of the performance, would rush to the check room, were clapping now like an enthusiastic audience, and they didn't move from their seats until "The Miss" came out three times in front of the curtain to show her appreciation. This one fact proves it more than anything that deep impression that Ruth St. Denis' phenomenal art made upon the audience . . . (13).

Poems were composed, and adulations recorded. The renaissance of the dance was hailed as complete, now that, after Fuller, Saharet, Duncan, and Maud Allen had revived dance, St. Denis had returned its original content, religion, to dance.

On her visit to the Ronacher Theatre in Vienna in February 1908, St. Denis introduced two new dances. The first, *The Nautch*, substituted for *Incense* on the opening night, February 5. It was a Carmen-like dance that appealed in a special way:

> To the song of the men and to the beating of a hand drum, she twirled herself with almost the imperturbable stiffness of a puppet, the figure remote in a laughing charm and a blissful childlike consciousness, while her veil drifts in remarkable ornamentation (3).

To a more select group in Vienna was presented the second new dance, *The Yogi*. At a special matinee, to which distinguished citizens were invited, St. Denis appeared in the simplest and most personal of all her dances. She dared to depict in movement the psychological strivings of a yogi to obtain samadhi. At the end, the audience didn't know if it should applaud, for, as one critic wrote:

> . . . a being out of another world performs there a divine service, a worship of nature, of her creations and arts. What the dancer displays is a splendid thing, wonderfully soul-stirring, like an expression of a strange art. Miss Ruth executes movements and gestures in a manner that effects one strangely, indescribably, as one cannot describe the walk of Duse. Ruth St. Denis works through her being. Each dance is only a movement play, a variation, a perspective of her own person. It was felt yesterday, in the wholly singular and artless dance, *Yogi*, that she needed not to make a step or a pirouette, in order to show that she is someone wholly exceptional and special, and in the second place to be thought of as a dancer (18).

Other critics echoed that it was a wholly exceptional dance.

During the rest of her vaudeville engagements, St. Denis did not use *The Yogi*. She made a brief run south to Monte Carlo (in which place she felt most ill at ease) and then went to Munich, not to the *spezialitätentheatre*, but to the Gartnerplatztheatre. She was presented, not with vaudeville acts, but with opera, two acts of *Fledermaus*. St. Denis' program was indeed now operatic in the grand manner, with her scenery, lights, and supernumeraries.

And for the first time she combined her five dances into the sequence that came to be known as "The East Indian Series." *Incense* was used as an invocative opener, *The Cobras* as the tour de force it was, followed by the gay and colorful all-dance *Nautch*. *The Yogi* provided a quick change of pace and mood, while the final *Radha* resolved the whole message. Such a program could very well be called grand opera. It looked back toward David Belasco's exotic and romantic productions in which St. Denis had danced small parts, but it also definitely pointed ahead to the vivid ballet productions of Diaghilev. This program of St. Denis' was an important foreshadowing of a time in which pure dance would find eager and enormous audiences.

Munich loved its dancers and had welcomed with open arms Duncan, Sacchetto, and Maud Allan, but "over her rivals Miss Ruth had an advantage: the extraordinary decorative and mysterious element with which she surrounds herself. And her public loves the mystery." Her starring was lengthened in Munich "because of her singular success" (10).

Similarly in Breslau, at the Schauspielhaus, she was combined, not with vaudeville acts but with several one-act plays. Her triumphal return, pure proof of her rise in artistic circles, however, was in May, 1908, at the Komische Oper in Berlin. There she was programed with short operas, such as Smetana's *Die verkaufte Braut.* By this time her performance had achieved a polish that was perfect—the smallest movement exactly in time with the faintest accompaniment, the slowest measured step nicely in contrast to the wildest whirlings: all "in a perfection which ensures pure aesthetic enjoyment; she is embodied grace and rhythm" (15). She had come full cycle, from a short act in the middle of one operatic scene, to full standing with operas of similar length as her own program. No greater proof is needed of her artistic achievement during her European years of triumph.

After appearing at the Kurhauses in Wiesbaden and Baden Baden, St. Denis left Germany for London in the summer of 1908. She did not go into variety houses there, but, financially secure for the first time in her life, she could afford to be "arty." She decided to present herself. La Scala Theatre was in an out-of-the-way location, but it was built like a temple and provided a perfect setting for her dances. Also, she could afford to be different from her two rivals, Duncan and Allan, both of whom had appeared in London in the interval since she had appeared at the Aldwych, and, incidentally, had helped to make dance the sensational topic it was at the moment:

> The present craze for symbolic dancing must surely have reached its limit in the performances of St. Denis which are now taking place at the beautiful, but hitherto unlucky Scala Theatre. To be able to fill a whole theatre programme with the gyrations of one person is almost incredible. Still more so is it to ensure a crowded auditorium. But such is the case. The large auditorium is nightly more than three parts full, stalls and pit alike, and when we consider that the actual performance does not last more than one hour and a quarter, and the intervals another half an hour, the zeal of the public for this form of entertainment borders on the extraordinary (11).

In keeping with the artistic tone of her offering, St. Denis introduced herself

as "Ruth St. Denis in Dances Interpreting Oriental Religions and Customs." She headed her program's numbers with *The Purdah, The Street, The Palace, The Forest,* and *The Temple,* keeping the same order she had found so successful in Munich.

She was now given much news coverage in the city which had hardly noticed her coming and going two years earlier. Lengthy discussions were carried on about the use of Delsarte movements in the contemporary renaissance of dance. The *Sketch Supplement* carried St. Denis' picture as Radha on its cover. From comparisons of the dancers Duncan, Allan, and St. Denis, which often found the passionate Allan in the lead, reviews ran to the hyperbolic "one of the most remarkable expositions of the art of dancing ever seen in England" (2). Full acceptance for St. Denis was achieved when she was asked to give a special performance by the patrons of La Scala Theatre. These included her old friends the Duchess of Manchester and Sir Lawrence Alma-Tadema and her Paris artist friend Rodin, as well as other leaders in the artistic world at that time. For the performance, she composed her first Japanese dance, *A Shirabyoshi,* a slight dramatization of a story by Lafcadio Hearn.

Meanwhile, her agent had been arranging bookings for her on the continent, and she returned there in December, 1908. Brief stands in Dresden, Chemnitz, Bielefeld, Weimar, Cologne, and Bonn, cities she had not visited before, and a return to the Wintergarten in Berlin, characterized her final two months in Germany. Her reputation was such that nothing but superlatives followed her appearances. In Weimar, in which place she appeared as an extra performance on a subscription series, her whole appeal was summed up in:

> Such an essence, which conceals in itself ancient wisdom, and is free while it is necessary, and is pure while it embraces the all with its heights and its abysses . . . such beauty portends for us who seek it an unforgettable experience and an immortal revelation (17).

From the German people, St. Denis received her greatest adulation and appreciation. She was loved and worshipped by all classes of Germans. Out of this climate of opinion rose a great personal tribute which she describes in her autobiography. Some artists and business men offered to build a theatre in her honor if she would remain in Germany for five years. The intensely patriotic St. Denis could not accept such an offer. With many regrets, she turned down the security of such a theatre and made preparations to return to America. A fitting climax, also, were the words of tribute in the *Kolnische Zeitung,* written on January 5, 1909, when she appeared at the Opernhause there:

> Her essence is a superior limb structure, as one finds only in the most perfect work of sculpture. It is almost a little severe, and more the Melonic than the Medeciian in its godlike beauty, with an extraordinarily developed suppleness of movement. The arms are wholly symmetrical, in contrast to the one-sided parterre gymnastics of today's ballet. And the essence is found especially in the permeation of the dances with spirit . . . The harmonious formation of the arms and this spirit-fullness of the dances are the two things which make this art appear remarkable, and at the same time a model for occidental

dance art . . . In any case, Ruth St. Denis provided for the public a special as well as a charming evening, which raised itself high above the quickly forgotten pleasing sight of a ballet scene (6).

The year was 1909; Diaghilev announced his first Russian ballet in Paris on March 18. St. Denis, unlike Duncan and Fuller, is never listed as a forerunner of the Russian ballet in ballet history books. Her influence may not have been as direct as Duncan's, whom Diaghilev has admitted and denied seeing in Russia, or as obvious as Fuller's, whose colors and lighting bathe every ballet production. Nonetheless, St. Denis' appearances to overwhelming approval in middle Europe introduced an exoticism and pictorialness in dance productions that were the same that Diaghilev made famous. Even Lincoln Kirstein, the balletomane *par excellent,* can see a relationship:

What did she [St. Denis] dance? It is hard for us to imagine today, when *Schéhérezade* badly done with only a faint echo of its meretricious pornography, is all that's left of the novel orientalism of the epoch . . . Her *Radha,* her *Cobra,* her *Yogi,* . . . might seem odder to us today than even *The Black Crook* (5).

On the other hand, her appeal, as of 1908, might not seem so odd today. She was a beautiful woman moving beautifully in an exotic setting. For this kind of a program, there is an audience in any century. And the three together were succeeding in elevating dance to a new position as an independent art form and were helping to train audiences who would take a whole evening of dance for its own sake.

Before returning to America in the fall of 1909, St. Denis recouped some of the financial losses incurred by her "arty" season at London's La Scala Theatre the year before. "The distinguished artist can also use money"; this time it was the London Coliseum, a vaudeville house that supported Diaghilev's company more than once, to which she went for ten weeks in the spring of 1909—at a fabulous salary of 500 pounds a week. Leading a varied vaudeville bill, she was the attraction which caused the "house full" board to be displayed. It was this ten weeks' turn for the general public, combined with the La Scala season for the intelligentsia, that made the dancer Ruth St. Denis a celebrity in London for the rest of her life. "The Coliseum may be congratulated," wrote the *London Times* in a rave review, "upon getting so artistic a dancer." She never danced down to her audience, the *Times* reported, but rather still gave *Radha* with its original aesthetic touch. The newspaper continued:

St. Denis conveys a rare impression of austerity. The rhythm of her dancing is not voluptuous, it is restrained; athletic actuality and ascetic in its refinement. Restraint is exercised so religiously that impulse is excluded. This is as it should be in a dance which symbolizes the renunciation of the senses (7).

A few weeks in Glasgow and Edinburgh, with a reported visit to the Moulin Rouge in Paris, closed St. Denis' personal triumph in Europe. It had been a spectacular and historic one.

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Relationship of Selected Factors in Growth Derivable from Age-Height-Weight Measurements

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Abstract

Growth curves were plotted on the Wetzel Grid for children in a Midwestern school (grades 1-8). In addition to the original measures of age, height, and weight, the measures of body shape, body size, rate of growth in the past year, developmental age, ratio of physical development, change in physique during the past year, and speed of growth were determined for each student. The interrelationships between these factors indicated that the rate of growth in the past year was strongly related to excessive deviation from normal growth; that excessive changes in physique and speed of growth were strongly related to ratio of physical development; that age and weight, age and size, height and weight, and height and size decreased in relationship as grade level increased; and that weight and body shape, weight and ratio of physical development, body shape and developmental age, body shape and ratio of physical development, body size and developmental age, body size and ratio of physical development, and developmental age and ratio of physical development increased in relationship as grade level increased.

SINCE Bowditch (4) presented his first comparison of the growth curves of boys and girls in 1872, the topic of physical growth has been of major interest to investigators. A large body of this research has been directed toward determination of the various relationships existing between growth measures.

Baldwin (1) reported correlations between height, weight, vital capacity, back strength, grip strength, and chest girth of boys and girls up to the age of 17 years. His age-height-weight tables were widely used to judge the quality of growth until recent years. Berkson (3) found correlations between height, weight, and chest circumference of boys at various ages. Lombard (8) developed norms for the breadth of bone and muscle for children by chronological age, thereby indicating some relationship between these factors.

Some studies emphasized the relationships between factors in growth other than height and weight. The Brush Foundation Study of Child Growth (12) showed, among other conclusions, correlations between successive measures of stature, weight, and percentage of terminal stature attained and skeletal age. Bayley (2) investigated size and body build of adolescents in terms of the relationship of these factors with skeletal maturing. Shuttleworth (11), studying physical growth characteristics in relation to age of achievement of maximum growth, concluded that groups classified as slow, average, or fast

in achieving maximum growth showed decidedly different growth patterns in a large variety of anthropometric measures.

Richey (9) and Shuttleworth (10) presented evidence that radical changes in the growth patterns of girls occur immediately before and during menarche. Other studies have related measures of height and weight to later measures of the same factors in an effort to form some basis for the prediction of growth. Illingworth and others (6) related the weight of children at birth to physical development during childhood. A study by Wilson (15) utilized correlations of height with height and weight with weight at selected times over a ten-year period. He concluded that an early measure of either trait related more highly with a late measure of the same trait than with measures of that trait taken during adolescence.

Although the majority of the studies conducted by physical education researchers have dealt with the relationship of anthropometric and growth factors with a particular physical trait, such as strength, and with motor performance, some studies have shown relationships between various anthropometric measures. Clarke (5) has published a review of these studies.

Statement of the Problem

The extensive use of growth charts as guidance and research instruments has introduced simple and direct methods of isolating characteristics of growth that have not received intensive study to date. This study was made to analyze a select group of these characteristics as determined from the Wetzel Grid.

The purpose of the study was to determine the degree of relationship that existed between certain anthropometric and growth factors as found from the actual growth patterns of elementary and junior high school children (grades 1-8). Measures studied included chronological age, height, and weight, and combinations of these measures as reflected in body shape, body size, developmental age, and ratio of physical development. All of these measures were of status at a given time.

Also studied were measures of progress. Included in this group were the rate of growth in the past year, change in physique during the past year, and speed of growth in the past year. All relationships were studied by grade groupings and by sex.

Procedures

The growth curves from which the data in this study were derived have been studied previously from the standpoint of the status of physique, changes in physique, and speed of growth (13).

In the collection of data, periodic measurements of height and weight were made of students in a selected elementary school over a five-year period. The first measurements were taken of the first four school grades. Each year thereafter the new first grade was added, and all previous groups were retained for study so that by the end of the fifth year all grades (1-8) were

under observation. The data collected reflect a combination of the longitudinal and the cross-sectional types of study. At the most, any given student's measurements are shown in the data for five consecutive grade levels, but some students' measurements were used at only one grade level.

Data in this study were determined from measurements taken on or near January 15, which was approximately the mid-point of the school year. Thus the measurements reflect those of the "middle" of each grade level.

Chronological ages were secured from official school records, originally documented by birth certificates. Height and weight measurements were made in street clothes, and with outer garments and shoes removed. The same measuring devices were used throughout the study.

The measurements of height and weight were plotted on the Wetzel Grid after each measurement period. The specific directions for determining the measures studied may be found elsewhere (14). Briefly, the measures were determined as follows:

1. The body shape of each subject was determined by the oblique channel of the grid in which his point of plotting fell. To find this measure, the height and weight were found on the appropriate scales at the top and left margins of the Grid panel. Lines were then extended from these points until they met on the panel.
2. The body size of the subject was determined by the developmental level which corresponded to the point plotted from initial height and weight measures. This level was read from the left margin of the physique channels.
3. Rate of growth in the past year was found by subtracting the developmental level of the previous year from that of the current year. This factor was expressed in the number of levels gained during the year.
4. Developmental age is the most likely chronological age of other boys or girls who are growing at the 67th percentile and who have the same body size. This value was found by tracing the developmental level from the left margin of the auxidrome panel until it intersected the 67 percent auxidrome. The age, read from the scale at the bottom of the panel, that corresponded to this point was the developmental age of the subject.
5. Ratio of physical development, called Developmental Quotient by Wetzel, was determined by dividing the developmental age of the subject by his chronological age. This is a rough measure of the degree of acceleration or retardation in growth of a particular child in comparison with the "normal" child of the same chronological age.
6. Change in physique during the past year was measured in terms of the degree of shifting from one physique channel to another between measurement periods. Students were classified as excessive deviates if the shift was greater than one-half channel per ten levels of development. Every student was placed in one of three categories—excessive deviate toward obesity, excessive deviate toward thinness, or normal in direction of growth.
7. Speed of growth was measured in terms of deviations in growth from predetermined tendencies to grow. Each student was classified as either a deviate in speed because of accelerated growth, a deviate in speed because of retarded growth, or normal in growth according to speed. Classification in this factor was made by comparing the actual growth curve, plotted on the auxidrome panel, with the corresponding point on the auxidrome curve selected by that subject as his preferred rate of growth.

Organization and Interpretation of Data

All measurements under investigation were classified into groups according to grade level of the student at the time of measurement. Grades 1-3 were then grouped together to represent the lower elementary level, grades 4-6 to

represent the upper elementary level, and grades 7-8 to represent the junior high level.

General Characteristics of Children Studied

The means and standard deviations of the anthropometric characteristics studied are shown in Table 1. The reader is cautioned that the first two school levels contain the composite scores of three grades, while the junior high school level is represented by only two grades. The means and standard deviations of chronological age, height, weight, body size, and developmental age are appreciably smaller for the junior high group than they would have been had an additional year of development been included, thereby giving all three groups the same length of time for the factors under study to develop.

Trends in chronological age, height, and weight were consistent with current knowledge of the development of these characteristics in children (7). The middle channel of the grid, indicating a medium body build, was the mean body shape at all levels of school. This is true even though there was a marked increase in the variability of body shape as grade level increased.

Body size showed some interesting trends. Approximately the same number of levels of development were gained in two years by the junior high school group as were gained by the upper elementary school group in three years. There also was a tendency toward increased variability in body size as the children progressed through school.

Significance of Relationships

The relationships for nonlinear factors are shown in Table 2. Size and speed of growth were significantly related (2 percent level of confidence) but the degree of relationship was relatively small. The larger children tended to be accelerated, the smaller retarded. The relative size of the child apparently could not be linked with sex or shifts in physique in the past year with any degree of confidence.

The rate at which the children grew in the past year had a definite influence on shifts in physique and deviations from normal growth in speed. The children who grew faster had a strong tendency to shift toward obesity and to grow at an accelerated rate. Those who grew more slowly tended to shift toward thinness and show a retarded speed of growth. Girls showed a slight tendency to grow faster than boys, and the upper grade levels increased in size at a much more rapid rate than did the lower levels.

No significant relationship was found between ratio of physical development and sex or grade level. A small but significant positive relationship was found between ratio of physical development and change in physique, and a slightly higher positive relationship was observed between ratio of physical development and speed.

The degree of relationship between other factors investigated in this study are shown in Table 3. The coefficient of correlations between chron-

TABLE 1.—MEANS AND STANDARD DEVIATIONS OF PERSONAL AND ANTHROPOMETRIC MEASURES BY GRADE LEVEL

	Grade Levels	Chronological Age (yrs.)	Height (in.)	Weight (lbs.)	Body Shape (channels)	Body Size (levels)	Developmental Age (yrs.)	Ratio of Physical Development
Mean	Grades 1-3	7.85	49.93	58.79	medium	70.32	9.17	1.14
	4-6	10.44	55.37	79.95	medium	102.10	11.64	1.12
	7-8	12.91	61.21	104.82	medium	131.59	13.94	1.08
	Total	*9.56*	*53.60*	*73.33*	*medium*	*91.28*	*10.80*	*1.12*
Standard Deviation	Grades 1-3	.83	2.58	9.12	1.52	15.89	4.00	.14
	4-6	.84	2.70	16.06	2.06	19.12	1.51	.12
	7-8	.52	2.32	16.89	2.22	15.62	1.30	.09
	Total	*1.88*	*4.54*	*20.18*	*1.86*	*27.02*	*3.30*	*.13*
Number of cases	Grades 1-3	N = 223						
	4-6	N = 223						
	7-8	N = 56						
	Total	N = 502						

TABLE 2.—SIGNIFICANCE OF RELATIONSHIPS BETWEEN SIZE, RATE OF GROWTH, AND DEVELOPMENTAL QUOTIENT AND OTHER SELECTED FACTORS

Relationships	N	Degrees of Freedom	χ^2	Level of Significance	Coefficient of Contingency
Size and:					
Change in Physique	363	10	10.38	50%	.17
Speed of Growth	363	10	21.20	2%	.23
Sex	582	4	4.23	55%	.09
Rate of Growth in Past Year and:					
Change in Physique	363	4	145.07	1%	.53
Speed of Growth	363	4	136.40	1%	.52
Sex	363	2	7.81	3%	.15
Grade Level	363	4	12.83	2%	.18
Ratio of Physical Development and:					
Change in Physique	363	8	30.43	1%	.28
Speed of Growth	363	8	67.28	1%	.40
Sex	363	4	3.13	60%	.09
Grade Level	363	8	12.50	13%	.18

ological age and height, weight, and body size decreased as grade level increased. At the lower level of school the relationships between these factors were moderate while at the upper grades they were relatively insignificant. Little relationship was found between chronological age and physique or ratio of physical development.

Height and weight showed a relatively high degree of relationship at the lower level of school, with the degree dipping sharply as grade level increased. Height and physique showed a very slight negative relationship. Height and size were highly related in the lower grades, and this relationship also declined as the children "grew up." Significant but small relationships existed between height and developmental age and ratio of physical development.

Weight showed an increasing relationship with physique as grade level increased. At the lower elementary level the relationship was small but significant. At the upper level of school the relationship was moderately high. The most surprising relationship found in the entire study was that between weight and body size as determined from the Grid. The coefficients were exceptionally high at all levels of school. Weight was highly related to developmental age in the upper elementary and junior high school grades. It was found to be more highly related to ratio of physical development as the student progressed from one school level to another.

Physique and body size were increasingly related as grade level increased, although the relationships were not exceedingly high. Physique and developmental age were slightly related at the lower elementary school level, and moderately related at the upper elementary and junior high school levels. The

TABLE 3.—RELATIONSHIP BETWEEN VARIOUS FACTORS IN GROWTH OF SCHOOL CHILDREN, GRADES 1-8

Factors	Grades	Height	Weight	Body Shape	Body Size	Developmental Age	Ratio of Physical Development
Chronological Age	1-3	.69	.62	.08	.64	.07	—.05
	4-6	.64	.46	.05	.50	.53	—.11
	7-8	.44	.20	—.09	.24	.29	—.15
	Total	*.90*	*.80*	*.01*	*.84*	*.51*	*—.15*
Height	1-3		.80	—.23	.84	.10	.48
	4-6		.66	.00	.73	.73	.39
	7-8		.49	—.17	.56	.57	.39
	Total		*.86*	*—.04*	*.91*	*.53*	*.14*
Weight	1-3			.38	.99	.22	.70
	4-6			.68	.99	.96	.78
	7-8			.76	.99	.93	.88
	Total			*.43*	*.98*	*.60*	*.38*
Body Shape	1-3				.31	.23	.42
	4-6				.63	.59	.65
	7-8				.71	.63	.71
	Total				*.36*	*.28*	*.53*
Body Size	1-3					.22	.70
	4-6					.98	.78
	7-8					.94	.87
	Total					*.61*	*.37*
Developmental Age	1-3						.11
	4-6						.79
	7-8						.90
	Total						*.19*

σr for all factors, grades 1-3 and 4-6 = .067
σr for grades 7-8 = .186

relationship between physique and ratio of physical development grew stronger as grade level increased.

Body size apparently was not highly related to developmental age in the lower grades, but was highly related in the upper levels. The relationship between body size and ratio of physical development was high at all levels, but progressively higher as grade level increased. Developmental age and ratio of physical development were only slightly related in the lower grades, but strongly related in the upper elementary and junior high school levels.

Summary and Conclusions

Growth curves of elementary and junior high school students, plotted over a five-year period on the Wetzel Grid, were analyzed to determine the interrelationships of selected anthropometric and growth characteristics. The following conclusions were reached as a result of this study.

1. The variability of body builds of children increases markedly as grade level increases, and the mean body build of these children at all school levels from lower elementary through junior high school is the medium build. The medium channel of the Grid evidently reflects the average body build of school children.

2. Students at the junior high school level grow faster than students at earlier grade levels when the rate of growth is measured by levels of development on the Wetzel Grid. In a previous study (13), no statistical significance was found in the number of growth failures in speed by grade level. The auxidrome panel evidently accounts adequately for this difference in speed.

3. The number of levels of development achieved by the student in a given period of time is a significant factor in marked deviations in growth curves from normal during this same period. Those growing more rapidly tended to become growth deviates by changes in physique and speed.

4. Excessive changes in physique and in speed of growth were reflected significantly in ratio of physical development.

5. The relationships between chronological age and height, chronological age and weight, chronological age and body size, height and weight, and height and body size decrease as grade level increases.

6. The relationships between weight and physique, weight and ratio of physical development, physique and developmental age, physique and ratio of physical development, body size and developmental age, body size and ratio of physical development, and developmental age and ratio of physical development increase as grade level increases.

7. Weight and size, as measured by the Wetzel Grid, are almost perfectly related at all grade levels. This relationship casts considerable doubt on the value of developmental level as an improved measure of body size.

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Effect of Various Activities on Whole Blood Viscosity[1]

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Abstract

Two hundred and thirty-eight unconditioned subjects were tested to determine to what extent whole blood viscosity was related to speed and endurance in swimming and running, strength exercises, extra water intake, and smoking. No evidence was found of an increase in blood viscosity after swimming 30 yd., running 50 yd., or smoking a cigarette. Group averages on whole blood viscosity were increased after performances in swimming 180 yd., running 440 yd., and performing strength activities. The mean average of the blood viscosity of the subjects decreased significantly after water intake. The high speed groups in swimming and running did not differ significantly, as far as blood viscosity was concerned, from the low speed groups in swimming and running. Wide variability in the effect of various activities on whole blood viscosity was found among the different groups of subjects.

LOUIS BENSON (3) found that the plasma viscosity of 361 apparently healthy individuals remained between 1.2 to 1.6, and that 294 adults with known disease processes had relative viscosity readings of 1.6 to 2.2. He wrote that an increase in viscosity has been observed to occur with an increase in peripheral resistance, capillary blood flow decrease, and cardiac work. Benson also remarked that blood viscosity is increased with ingestion of large amounts of protein and fat; and that the blood becomes more viscous in subjects participating in vigorous physical exercise.

Bainbridge (1, p. 96) stated the following:

> . . . the circulation rate during exercise, and therefore the blood supply to the body as a whole, is also influenced by other changes of subsidiary importance. These include dilatation of the vessels of the skin, rise of the temperature of the body, and concentration of the blood by loss of water. Dilation of the vessels of the skin will tend to lower the blood-pressure by increasing the capacity of the circulatory system and by lessening the peripheral resistance. The rise of temperature also lessens the peripheral resistance insofar as it diminishes the viscosity of the blood. These effects will be, at least in part, counteracted by the increased viscosity of the blood brought about by the concentration of the blood which takes place during exercise.

Schneider and Havens (8) reported that physical exertion increased the percentage of hemoglobin, erythrocytes, and leukocytes in the blood. They imply that this greater concentration of blood causes an increase in the specific gravity in proportion to the increase in the red corpuscles.

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Boothby and Berry (4) found an increase of the percentage of hemoglobin (increase in the number of red corpuscles). They stated that there is no increase in red corpuscles if there is no sweating. They thought that the increase in red corpuscles in exercise, and therefore the greater the density of the blood, was due to the withdrawal of the watery elements accomplished through perspiring. However, Hawke (6) felt that if a run of only 100 yards produced an increase in the concentration of blood, some other factor must be concerned in its production. Bainbridge and Trevan (2) and F. H. Scott (9) thought the increased formation and rapid filtration of lymph during exercise furnished an adequate explanation for the concentration of blood.

Rakestraw (7) found an increase in the number and the relative volume of the corpuscles during exercise but found only a slight increase in the viscosity of blood. Determann, as cited by Bainbridge (1), also observed only an insignificant change in the viscosity of the blood during exercise. Bainbridge conjectured that it was very probable that the rise of temperature and the concentration of blood practically neutralize one another.

Thompson (10) tested 34 male subjects to determine to what extent swimming 300 yd. within six minutes affected the blood viscosity of trained swimmers. His findings indicated that participation of conditioned subjects in vigorous swimming is not an important factor in causing blood to become more viscous. He also found a wide individual variability in the effect of swimming on blood viscosity. In other words, exercise seems to cause blood viscosity to increase for some conditioned individuals but to decrease for others. These varying opinions and reported findings stimulated the present study.

Purpose of the Study

The primary purposes of this study were to determine to what extent various activities affected whole blood viscosity; more specifically, to determine what effect the following performances had on blood viscosity: (1) swimming a 30-yd. sprint at full speed; (2) swimming 180 yd. at full speed; (3) running a 50-yd. dash at full speed; (4) running 440 yd. at maximum speed; (5) vigorous strength exercise; (6) drinking one pint of water; and (7) smoking one regular-size cigarette.

Procedures

The total number of subjects used in this study was 238. They were enrolled in the men's required physical education program at the Pennsylvania State University. The subjects used in the swimming, running, and strength exercises were not conditioned for the events.

For motivation purposes, money awards were offered for those individuals with the fastest time in the 30-yd. sprint swim, 180-yd. swim, 50-yd. dash, and 440-yd. run—$5 for first place, $3 to second place, and $2 to third place. In addition to these awards, a letter grade of "A" was promised to all individuals who participated in the study, providing the participants in the experiment

followed all rules and regulations of the experiment and all regulations pertaining to regular classes at the University.

SWIMMING

The subjects in this activity were 63 male students between the ages of 17 and 28. They were enrolled in three different classes of a 16-week life saving course. The swimming was done in the Glennland swimming pool, which measured 90 ft. by 45 ft. The average air temperature within the pool area was 83°F., and the average water temperature was 86°F.

During the first class meeting the instructor rated subjectively every student of all the classes on his ability to do the American crawl stroke. All students who did not receive a "4" rating (a number rating arbitrarily set up which designated a fairly high degree of execution of the stroke) were eliminated from the experiment. After the elimination trials, the 63 students selected were divided into groups. One group comprised of 35 students was designated as the 30-yd. sprint swimmers, and the other group of 28 subjects was designated as the 180-yd. endurance swimmers. All the subjects were taught a racing entry into the water, and in addition, the endurance swimmers were taught an open turn. At specified times, these subjects reported to the tester to have their blood samples taken and to swim their particular events.

Each subject was timed by an experienced timer with a stop watch calibrated in tenths of a second. The timer stood directly behind the swimmer when he started. The swimmer started at his discretion. As the swimmer's feet left the end of the pool, the timer started the stop watch. If the swimmer was swimming a 30-yd. sprint, the timer trotted to the opposite end of the pool and stood directly above the swimmer's lane. The watch was stopped when the swimmer first touched the end of the pool with either hand. For an endurance swimmer, the timer remained stationary but otherwise followed the same procedures for starting and timing. The time of each performer was recorded.

In order to determine if whole blood viscosity was related to speed in swimming, the 35 30-yd. sprint swimmers and the 28 180-yd. endurance swimmers were divided into two groups according to the time scores they had received during the swimming events. The 17 students with the fastest times in the 30-yd. sprint and the 14 students with the fastest times in the 180-yd. endurance swim were classified as the "fast" groups and the individuals with the slower times as the "slow" groups.

RUNNING

The subjects in this phase of the study were 56 male students between the ages of 17 and 23. They were enrolled in two different classes of a 16-week beginning swimmer's course. One class of 28 subjects was designated as the 50-yd. dash group, and the other class of 28 subjects was designated as the 440-yd. run group. Both classes were taught a sprinter's start. The subjects did their running on the indoor track at Recreation Hall, which is a 220-yd. oval, wooden track. At a set time the subjects reported to the tester

to have their blood extracted and to be timed for their specified event.

The 50-yd. dash men required a starter and an experienced timer. The starter shouted the command "go," and simultaneously dropped a handkerchief. As the timer saw and heard the starter, he started the stop watch which was calibrated in tenths of a second. On the command of "go," the runner began the dash. As the runner crossed the finish line breaking the string, the timer stopped the watch. Each 440-yd. runner started at his discretion. As he moved one of his feet for the first stride, the timer started the watch. When the runner broke the string crossing the finish line, the watch was stopped.

To determine if whole blood viscosity was a factor in speed in running, the 28 50-yd. dash men and the 28 440-yd. runners were divided into two groups according to the times made on the running events. The 14 subjects in each group of the two events with the fastest times were designated as the "fast" groups and the individuals with the slower times as the "slow" groups.

STRENGTH

The subjects in this activity were 20 male students between the ages of 18 and 21. They were enrolled in a weight training class held at Recreation Hall.

The students were taught various lifts and exercises during the first class period. These lifts and exercises were then used to determine if blood viscosity was affected by strength activities. The subjects were required to have their blood sample taken before and after the strength exercises. These exercises were as follows: (1) three minutes of skeleton dancing; (2) two chin pulls executed slowly; (3) five squats with 100 pounds on bar; (4) five military presses with 40 pounds on bar; (5) five toe raises with 100 pounds on bar; (6) ten sit-ups with 10-pound weights behind head; and (7) five push-ups.

DRINKING WATER

This group of subjects was composed of 28 male students who were enrolled in the three life saving courses but who were not selected to participate in the swimming events. The ages of these students ranged from 17 to 22 years. These subjects simply reported to the tester to have the blood sample taken before and after drinking one pint of water.

SMOKING

The subjects in this phase of the study were 28 male students between the ages of 18 and 23. They were enrolled in an instructor's swimming course. These subjects were required to have their blood sample taken before and after smoking one regular size cigarette. All the subjects were habitual smokers.

TESTING

All testing was done between the hours of 10 and 11 o'clock in the morning. On the night before the specified day of testing, each subject slept for eight

hours. The next morning he ate a breakfast consisting of one cup of tea, two pieces of toast, one small bowl of cereal with no sugar, and one glass of fruit juice. The subjects did not participate in any type of vigorous exercise on the same day before the testing, except walking to and from their regularly scheduled classes at the University.

Upon reporting for the test, the subjects either removed or changed all their clothing. They did not take a shower, but washed and dried their hands thoroughly. Each student then sat in an upright position on a bench for a period of ten minutes.

After the ten-minute rest period had elapsed, each subject had blood extracted from the medius finger of the left hand by means of a spring lancet. The blood was immediately placed in a Hellige viscometer to determine its relative viscosity.

As soon as each subject had his blood sample taken, he participated in the activity. After finishing the activity, the subject washed and dried his hands thoroughly. The smoker group and water-drinking group rested for a 15-minute period after the smoking or drinking of the pint of water respectively. Then blood was taken from the medius finger of the left hand of these subjects and immediately placed in the viscometer.

USE OF THE VISCOMETER

The viscometer was placed on a sturdy, level desk with the end containing the pressure stock at the left when one faced the instrument. Two calibrated capillaries were placed in the instrument with the calibrated end of each

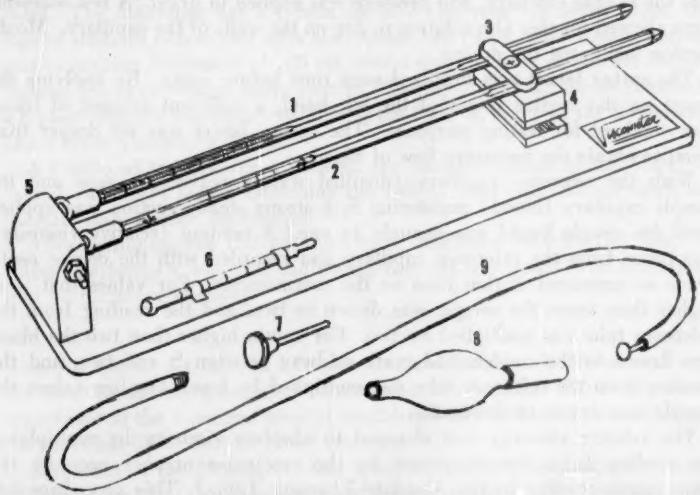

FIGURE I. Hellige Viscometer No. 1200. Labeled parts are (1) reference capillary, (2) sample capillary, (3) spring clip, (4) leveling mechanism, (5) pressure stock, (6) thermometer, (7) rubber pad for pressure adjustment, (8) draining bulb, and (9) pressure tubing.

capillary to the left, then partially filled with distilled water. The calibrated ends were inserted in pressure outlets and the opposite ends under the spring clip. The capillaries were leveled by means of raising or lowering the right end by turning the knurled knobs.

After use, each capillary was washed thoroughly with distilled water and occasionally with a solution of chromic acid, sulfuric acid, and distilled water. After distilled water had been used, alcohol was put in each capillary and then removed and allowed to dry several minutes. Suction was applied to speed the drying process. It was very important that each capillary be cleaned because even the slightest dust particle would have produced different surface tension effects on the fluid.

The reference tube, calibrated from zero to seven, was filled with the reference liquid (distilled water). After wetting the column its entire length, the distilled water was returned to zero. The sample tube, calibrated from S to five-tenths was filled with the sample liquid (blood). The blood was drawn through the entire column and returned to S. The distilled water was put in the reference tube by a medicine dropper, and the blood was drawn into the sample tube directly from the finger by suction. Care had to be taken not to allow air bubbles to enter the capillary.

An anti-coagulant of heparin and distilled water was used because of its practibility (5). A solution of .5 percent heparin in distilled water (.05 ml. heparin to 10 ml. distilled water) was mixed just before the drawing of any blood. With suction and the medicine dropper the solution was pulled into the sample capillary, and pressure was applied to drain. A few moments were allowed for this film solution to dry on the walls of the capillary. Mouth suction facilitated the drying.

The spring lancet was sterilized each time before using. By applying the lancet on the medius finger of the left hand, a sufficient amount of blood was obtained for testing purposes. The spring lancet was set deeper than usual to obtain the necessary flow of blood.

With the reference capillary (distilled water) registering zero and the sample capillary (blood) registering S, a strong steady suction was applied until the sample liquid was brought to one. A reading (relative viscosity) was taken from the reference capillary and recorded with the degree centigrade as measured at that time on the thermometer. For values that were higher than seven the sample was drawn to two, and the reading from the reference tube was multiplied by two. For values higher than two the blood was drawn to the unidentified mark midway between S and two, and the reading from the reference tube was multiplied by four. For low values the sample was drawn to five-tenths.

The relative viscosity was changed to absolute viscosity by multiplying the reading from the viscometer by the centipoise number opposite the temperature reading in the Absolute Viscosity Table.[2] This procedure followed all preliminary computations if the sample reading was higher than one.

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[2] This table is listed in the *Directions for Hellige Viscometer No. 1200.*

Analysis of Data

SWIMMING

30-Yd. Sprint Swim. The difference between the mean blood readings before and after swimming the 30-yd. sprint had a critical ratio of .56 which is not significant; i.e., a 30-yd. sprint swim would not seem to be an important factor in blood becoming more viscous.

The blood of 20 of the 35 30-yd. sprint swimmers recorded greater viscosity. The blood of 14 of the swimmers recorded less, and one performer's whole blood viscosity remained unchanged.

An insignificant t ratio of 1.30 was obtained between the blood viscosity readings before swimming of the "fast" and "slow" 30-yd. sprint swimmers. The mean blood viscosity of the "fast" swimmers was .13 centipoises higher than that of the "slow" swimmers before participating in the event.

A t ratio of 1.55 was obtained between the whole blood viscosity readings of the "fast" and "slow" swimmers after swimming 30 yards. This t ratio is not significant at the 5 percent level of confidence and indicates that blood viscosity is not an important factor in 30 yd. sprint swimming. The viscosity reading of the "fast" swimmers lowered during the exercise and the viscosity is not an important factor in 30-yd. sprint swimming. The vis- were not significant; i.e., they were well within the range of chance fluctuation.

180-Yd. Swim. The mean blood readings of these swimmers was .22 centipoises higher after swimming the 180 yards than before swimming the event. The difference has a t ratio of 3.67 (between the mean blood readings of students before and after they swam 180 yds.). This t ratio indicated that swimming a distance of 180 yd. would seem to be a significant factor in causing blood to become more viscous. Twenty-two of the 28 swimmers had a higher viscosity score after swimming the 180 yd., and 6 of the 28 swimmers had a lower viscosity reading.

A t ratio of the difference between the blood readings of the "fast" and "slow" swimmers before swimming the 180 yd. was only .32, so small as to indicate only chance fluctuation.

After swimming the 180 yd. the t ratio difference between the "fast" and "slow" performers was .73, indicating that relative speed was unrelated to past performance viscosity.

RUNNING

50-Yd. Dash. A t ratio of 1.86 was obtained between the blood readings of the 28 subjects before and after running the 50-yd. dash. This t ratio was not significant at the 5 percent level of confidence and indicated that a run up to 50 yards has little effect on blood viscosity.

Seventeen of the 28 subjects had a higher viscosity reading after running 50 yards; and 7 of the 28 subjects had a lower reading. The readings on four of the subjects remained the same.

TABLE 1.—CRITICAL RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 35 SUBJECTS BEFORE AND AFTER SPRINT SWIMMING 30 YARDS

Whole Blood Viscosity Readings	M	S.D.	$S.E._M$	r	Critical Ratio
Before Swimming 30 yds.	1.31	.28	.05	.19	.56[a]
After swimming 30 yds.	1.35	.35	.06		

[a] Not significant at the 5 percent level of confidence.

TABLE 2.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 17 FAST AND 18 SLOW 30-YD. SPRINT SWIMMERS BEFORE AND AFTER SWIMMING

Participants		M	S.D.	S.E.M.	T Ratio
Before Swimming	"Slow" Swimmers	1.37	.34	.09	1.30[a]
	"Fast" Swimmers	1.24	.18	.04	
After Swimming	"Fast" Swimmers	1.26	.27	.07	1.55[a]
	"Slow" Swimmers	1.43	.39	.09	

[a] Not significant at the 5 percent level of confidence.

TABLE 3.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 28 ENDURANCE SWIMMERS BEFORE AND AFTER SWIMMING 180 YARDS

Whole Blood Viscosity Readings	M	S.D.	S.E.M	r	T Ratio
Before Swimming 180 Yds.	1.18	.15	.03	.05	3.67[a]
After Swimming 180 Yds.	1.40	.28	.05		

[a] Significant beyond the 1 percent level of confidence.

TABLE 4.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 14 FAST AND 14 SLOW ENDURANCE SWIMMERS BEFORE AND AFTER SWIMMING

Participants		M	S.D.	S.D.M	T Ratio
Before Swimming	"Fast" Swimmers	1.17	.14	.04	.32[a]
	"Slow" Swimmers	1.19	.16	.04	
After Swimming	"Fast" Swimmers	1.44	.34	.09	.73[a]
	"Slow" Swimmers	1.36	.20	.06	

[a] Not significant at the 5 percent level of confidence.

TABLE 5.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 28 SUBJECTS BEFORE AND AFTER RUNNING THE 50-YD. DASH

Whole Blood Viscosity Readings	M	S.D.	S.E.M	r	T Ratio
Before Running 50-Yd. Dash	1.17	.13	.03	.10	1.86[a]
After Running 50-Yd. Dash	1.24	.16	.03		

[a] Not significant at the 5 percent level of confidence.

TABLE 6.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 14 FAST AND 14 SLOW 50-YD. DASH MEN BEFORE AND AFTER SPRINTING

Participants		M	S.D.	S.D.M	T Ratio
Before Running	"Fast" Runners	1.18	.12	.03	.44[a]
	"Slow" Runners	1.16	.13	.04	
After Running	"Fast" Runners	1.23	.17	.05	.16[a]
	"Slow" Runners	1.24	.15	.04	

[a] Not significant at the 5 percent level of confidence.

TABLE 7.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 28 SUBJECTS BEFORE AND AFTER RUNNING THE 440-YD. DASH

Whole Blood Viscosity Readings	M	S.D.	S.E.M	r	T Ratio
Before Running 440-Yd. Dash	1.17	.16	.03	.79	3.93[a]
After Running 440-Yd. Dash	1.28	.23	.05		

[a] Significant beyond the 1 percent level of confidence.

TABLE 8.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 14 FAST AND 14 SLOW 440-YD. RUNNERS BEFORE AND AFTER RUNNING

Participants		M	S.D.	S.D.M	T Ratio
Before Running	"Fast" Runners	1.17	.13	.04	.14[a]
	"Slow" Runners	1.18	.18	.05	
After Running	"Fast" Runners	1.28	.20	.06	.0[a]
	"Slow" Runners	1.28	.26	.07	

[a] Not significant at the 5 percent level of confidence.

An insignificant t ratio of .44 was computed between the whole blood viscosity readings of the "fast" and "slow" runners before either group ran the 50 yards.

A t ratio of only .16 was obtained between the blood readings of the "fast" and "slow" runners after both groups ran the 50-yd. dash. This t ratio indicated that whole blood viscosity was seemingly unrelated to running a 50-yd. sprint.

440-Yd. Run. A t ratio of 3.93 was obtained between the blood viscosity readings of 28 subjects before and after a 440-yd. run. This t ratio indicated that running a distance as far as 440 yards would seem to be a factor in causing blood to become more viscous.

The blood of 22 of the 28 subjects was recorded as more viscous after running 440 yards, and the blood of four of the subjects as less viscous. Two subjects had the same readings before and after the running.

The difference in the blood viscosity of the "fast" and "slow" runners was insignificant (t = .14, from samples taken before the run). Apparently blood viscosity as measured in this group was unrelated to speed.

TABLE 9.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 20 SUBJECTS BEFORE AND AFTER STRENGTH EXERCISES

Whole Blood Viscosity Readings	M	S.D.	S.E.M	r	T Ratio
Before Strength Exercises	1.16	.10	.02	.008	3.72[a]
After Strength Exercises	1.45	.33	.08		

[a] Significant beyond the 1 percent level of confidence.

TABLE 10.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 28 SUBJECTS BEFORE AND AFTER DRINKING ONE PINT OF WATER

Whole Blood Viscosity	M	S.D.	S.E.M	r	T Ratio
Before Drinking	1.37	.31	.06	.62	2.92[a]
After Drinking	1.23	.24	.05		

[a] Significant beyond the 1 percent level of confidence.

TABLE 11.—T RATIO BETWEEN WHOLE BLOOD VISCOSITY READINGS OF 28 SUBJECTS BEFORE AND AFTER SMOKING ONE CIGARETTE

Whole Blood Viscosity	M	S.D.	S.E.M	r	T Ratio
Before Smoking	1.23	.16	.03	.21	1.54[a]
After Smoking	1.31	.24	.05		

[a] Not significant at the 5 percent level of confidenee.

STRENGTH

A t ratio of 3.72 was obtained between the mean blood viscosity readings before and after the strength exercises of 20 subjects. This t ratio indicated that such activities had an influence on blood viscosity. The blood of 17 of the 20 subjects was more viscous after participating in the strength exercises, one subject's blood was less viscous, and two of the subjects had the same readings before and after the activity.

DRINKING WATER

The difference in means of blood viscosity of 28 subjects before and after drinking one pint of water was significant ($t = 2.92$). The viscosity of blood would seem to be lessened after a subject consumes a pint of water. The blood viscosity readings of 19 of the 20 subjects were lower after drinking one pint of water, and the readings of eight were higher. One subject's blood remained unchanged.

SMOKING

An insignificant t ratio of 1.54 was obtained between the blood viscosity readings of 28 smokers before and after smoking one regular-size cigarette. This t ratio indicated that the blood viscosity of habitual smokers was not affected by smoking one cigarette.

The readings of 15 of the 28 subjects showed an increase in blood viscosity after smoking a cigarette, and 9 of the 28 subjects showed a decrease. Four of the subjects showed neither an increase nor a decrease in the viscosity readings.

Summary and Conclusions

This study was conducted in order to investigate whether whole blood viscosity was related to maximum rate of performance, or affected by the activity in the following: (a) swimming 30 yards; (b) swimming 180 yards; (c) running 50 yards; and (d) running 440 yards. The effects of strength exercises, of drinking one pint of water, and of smoking a cigarette were also investigated. In other words, the attempt was made to determine (1) whether an individual's level of maximum performance was related to less blood viscosity, and (2) whether various activities in themselves affected blood viscosity.

On the basis of this particular study, the following conclusions appear warranted:

1. Whole blood viscosity of unconditioned subjects did not increase with the swimming of 30 yards.
2. Participation of unconditioned subjects in swimming 180 yards was accompanied by an increase in blood viscosity.
3. Unconditioned sprinters did not show a significant rise in blood viscosity in running 50 yards.
4. A 440-yd. run by unconditioned runners was accompanied by a significant increase in blood viscosity.
5. Strength exercises raised significantly the blood viscosity of unconditioned subjects.
6. The smoking of one cigarette by habitual smokers produced no change in viscosity of their blood.
7. Drinking one pint of water caused a decrease in whole blood viscosity.
8. The viscosity of the blood of "fast" swimmers and runners was not significantly different from that of "slow" swimmers and runners.
9. There was wide variability in the effect of various activities on whole blood viscosity. Some activities seem to cause blood viscosity to increase for certain individuals, decrease for others, and remain unchanged for still others.

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Notes and Comments

NOTES

Bowling Norms for College Men and Women

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THE PURPOSE OF THIS STUDY was to establish norms which might be used for evaluating and classifying college men and women of different bowling skill levels.

Phillips and Summers (1) in 1950 reported the need in regular college classes for norms at different levels of ability. In an extensive study involving 28 colleges and universities, they established norms and learning curves for college women. There appears to be a need for the establishment of similar norms for college men.

In addition to final achievement, the investigator was interested in examining the bowler's application of his knowledges and skills learned during the instruction period as indicated by his improvement in average scores. The norms may also serve as a motivating device and an aid in guidance as well as in evaluation of student bowling abilities.

This study, therefore, attempts to determine (1) bowling norms for final achievement and (2) improvement norms for college men and women in regular physical education classes at the University of California, Los Angeles.

Procedure

Subjects for the study were 704 freshmen and sophomore male and female students enrolled in bowling classes in the general college student (required) program at the University. For purposes of this study and more efficient instruction, each class was divided into beginning, intermediate, and advanced groups.

At the close of the second week of instruction, students were classified into these skill levels according to criteria resulting from a pilot study completed by the investigator the year prior to this study. These criteria were (1) student self-evaluation of previous experience—those students who stated or demonstrated they had not bowled before were classified as beginners and (2) demonstration of ability as exemplified by an average score of the initial five lines of bowling. The students were then assigned to beginning, intermediate, or advanced groups according to the following norms established in the pilot study:

Ability Grouping	*Men*	*Women*
Beginning	120 or under	98 or under
Intermediate	121-145	99-119
Advanced	146 and over	120 and over

These three ability groupings were determined by computing mean scores and standard deviations within each grouping. Norms were then developed in five categories—superior, good, average, poor, and inferior according to a normal distribution. For example, the superior category included the scores two standard deviations above the mean; the good category included those from +.6 standard deviations above the mean to +1.9 standard

deviations above the mean; the average category from —.5 to +.5 standard deviations from the mean; the poor from —.6 to —1.9 standard deviations below the mean; and the inferior two standard deviations below the mean. The upper limits of the average category in each group were used to determine beginning, intermediate, and advanced bowlers.

After initial classification there were 162 male and 292 female subjects in beginning groups, 155 male and 58 female subjects in intermediate groups, and 37 male and no female subjects in advanced groups.

Data were gathered over a period of three years in 19 bowling classes of approximately 36-40 students per class. Each class met twice a week for 13 weeks. Each student bowled 2-3 lines per week for a total of approximately 26-35 lines of bowling. For purposes of this study, final averages were recorded after 26 lines since all students had completed at least 26 lines. Records were kept week by week of the cumulative average of each student. This average was computed by dividing the total number of pins knocked down in each three-game series by the number of lines bowled.

Two different scores were recorded for each subject:

1. Final cumulative average at the end of the instruction period.
2. Improvement score, determined by subtracting the average score at the end of the fifth line of bowling from the final cumulative average.

There were a few cases, particularly in the intermediate and advanced categories, where students' final averages did not show improvement over their initial averages. In these cases the final averages were subtracted from the initial averages and recorded as a minus number of pins improved.

Treatment of Data

In order to set up norms for final averages, means and standard deviations were computed. This was done separately for male subjects and for female subjects at each skill level.

Data were treated in the same manner as in the pilot study, that is, from the mean scores and standard deviations at each skill level, norms were established in five categories—superior, good, average, poor, and inferior, according to a normal distribution.

Norms at different levels of ability for men and women appear in Table 1.

TABLE 1.—BOWLING NORMS FOR COLLEGE MEN AND WOMEN

Rating	Scores					
	Beginning		Intermediate		Advanced	
	Men	Women	Men	Women	Men	Women
Superior	127 & above	113 & above	150 & above	125 & above	162 & above	None
Good	116-126	101-112	140-149	120-124	157-161	
Average	107-115	93-100	126-139	115-119	152-156	
Poor	96-106	81-92	115-125	110-114	147-151	
Inferior	95 & below	80 & below	114 & below	109 & below	146 & below	
N	162	292	155	58	37	
Range	86-132	70-123	107-155	101-135	143-174	
M	111.26	97.31	134.42	117.11	154.46	
SD	8.22	8.18	7.33	4.02	4.41	

It can be observed from Table 2 that the mean scores tend to increase from the beginning skill level to the advanced, whereas standard deviations tend to decrease from the beginning level to the advanced. There is a statistically significant difference between male and female bowlers at better than the .01 percent level of confidence as shown by the magnitude of the student t ratio. The hypothesis that this difference is attributed to

TABLE 2.—COMPARISON OF SCORES OF MALE AND FEMALE BOWLERS, CLASSIFIED BY SKILL LEVEL

Skill Level	N	M	SD	df	t	Level of confidence
Male Beginner	162	111.26	8.22			
Female Beginner	292	97.31	8.18	453	18	.01
Male Intermediate	155	134.42	7.33			
Female Intermediate	58	117.11	4.02	212	22	.01
Male Advanced	37	154.46	4.41			

TABLE 3.—COMPARISON OF SCORES OF MALE AND FEMALE BOWLERS AS SHOWN BY MEANS AND STANDARD DEVIATIONS OF IMPROVEMENT SCORES

Skill Level	N	M	SD	df	t	Level of confidence
Male Beginner	124	10.06	5.16			
Female Beginner	206	10.81	5.11	328	.670	not significant
Male Intermediate	90	4.92	3.25			
Female Intermediate	43	4.19	3.21	131	.695	not significant
Male Advanced	13	−1.08				

chance is thus rejected; therefore it seems advisable to establish separate norms for male subjects and female subjects.

The same statistical procedure was followed in setting up improvement norms. From the mean scores and standard deviations at each skill level, norms were established in the same five categories—superior, good, average, poor, and inferior.

The investigator is aware that the development of relative measures for evaluating student progress, particularly in the area of motor skills, is difficult, and often these measures do not prove to be valid criteria for judging improvement. Some effort in that direction seems better than none, however. Therefore, the improvement norms, based upon preclassification of bowlers, serve as an additional evaluating tool and motivating device for students enrolled in bowling classes at UCLA.

It can be observed from Table 3 that there was no appreciable difference in mean scores or in standard deviations between male and female bowlers in either beginning or intermediate categories. Since there were no female advanced bowlers and so few cases of male subjects in this category, statistics were not completed for this group.

There was no significant difference between the sexes in improvement scores, consequently only one set of norms was established for evaluating men and women.

Norms for improvement at different levels of ability appear in Table 4.

A comparison between beginning and intermediate bowlers (male and female) was made by computing the means and standard deviations for each of these skill levels.

From Table 5 it seems evident that the mean improvement score of beginning bowlers is more than twice the score for intermediate bowlers, yet the standard deviation of the beginning group is only slightly above that of the intermediate group.

TABLE 4.—BOWLING IMPROVEMENT SCORES FOR MEN AND WOMEN

Rating	Scores		
	Beginning	Intermediate	Advanced
Superior	21 & over	11 & over	not computed
Good	15-20	8-10	
Average	8-14	3-7	
Poor	2-7	−1 to +2	
Inferior	1 or less	−2 & lower	
N	330	133	13
Range	−9 to +29	−12 to +22	not computed
M	11.22	5.08	
SD	5.34	4.17	

TABLE 5.—COMPARISON OF SCORES OF BEGINNING AND INTERMEDIATE BOWLERS AS SHOWN BY MEANS AND STANDARD DEVIATIONS OF IMPROVEMENT SCORES

Skill Level	N	M	SD	df	t	Level of confidence
Beginning (Male & Female)	330	11.22	5.08		5.05	.01
Intermediate (Male & Female)	133	5.34	4.17	471		
Advanced (Male)	13	−1.44				

Conclusions

The purpose of this study was to establish bowling norms which might be used in evaluating and classifying college men and women at different skill levels. Final averages and improvement scores were recorded for 704 students. Norms based on these data were developed.

Final Average Norms. There is a need for norms at different levels of bowling ability as well as for male and female bowlers. After 26 lines bowled during class instructional periods, the male subjects were significantly different from the female subjects with regard to final average scores, but there was no significant difference in improvement scores.

Improvement Norms. Beginning and intermediate groups both showed improvement from their first to final averages. However, the beginning group's average improvement scores were significantly higher than those of the intermediate group. It might be assumed that this results in part from the learning potential of beginning bowlers as compared with that of intermediate bowlers who had already attained a degree of skill prior to the class instructional period.

It is hoped that future study may reveal more definite reasons for the lack of improvement in some individuals. However, the investigator was aware that some of these individuals were interested in experimenting with different bowling techniques in the middle of the semester. This attempt to change habit patterns may have resulted in a drop in scores. Reasons for lack of improvement in scores of certain intermediate bowlers should be investigated further.

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(Submitted 3/26/59)

The Booth Scale as a Predictor of Competitive Behavior of College Wrestlers

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IN A PREVIOUS issue of this journal (1) Booth[1] described the construction and use of a written test designed to predict the competitive behavior of athletes. His scale is composed of 40 true-false questions: 22 questions selected from the Minnesota Multiphasic Personality Inventory on the basis of ability to discriminate significantly between poor and good competitors; 15 questions comprising the *L* (*Lie*) scale in that Inventory; and 3 other questions chosen at random to provide a 40-item battery. He correlated the scores made on the test by 21 collegiate track men with the coach's estimate of each man's competitive behavior and reported that $r = .63$, which was statistically significant at the .05 level. Hence he concluded that the battery discriminated significantly between poor and good competitors. The purpose of the present investigation was to determine the validity of this test when used to predict the competitive behavior of college athletes participating in a physical contact sport.

Procedure

The Booth competitive behavior test was administered to 11 varsity wrestlers at the University of California at Los Angeles and to 24 varsity wrestlers at the University of Oklahoma. At the conclusion of the wrestling season each of the coaches of the two schools (Hunt and Robertson) ranked his wrestlers in the order of their competitive behavior as observed during the season. This ranking was based upon competitive spirit (determination of the athlete to win) and competitive performance (actual performance as compared with that which might reasonably be expected from the athlete) as prescribed by Booth. Neither the coaches nor the subjects had any knowledge of the scores on the test battery, as the scales were graded by the remaining co-author (Rasch) and the findings were kept confidential. In accordance with the routine methodology, subjects who had *L* scores of seven or above were eliminated from the study. As a result two subjects were dropped from the University of California group. Scores made by the remaining subjects on the 22-item competitive behavior scale were then correlated with the ranking assigned to them by their coaches. The results were analyzed statistically by use of Spearman's Rank-Difference Correlation Method (Spearman *Rho*). No score was considered statistically significant unless the chance occurrence of such a statistic was 5 percent or greater.

Results and Conclusions

The results for the two groups of subjects are shown below.

College	No. Of Subjects	Rho Coefficient	Significance
U. C. L. A.	9	.500	$\leqq .05$
U. of Oklahoma	24	.171	$\leqq .05$

[1] The writers are indebted to Dr. Booth for his advice on and interest in the conduct of this investigation and to the wrestlers who cooperated in the study.

In view of these findings it was concluded that the Booth competitive behavior scale did not give a satisfactory prediction of the competitive behavior of these subjects as judged by their coaches.

It is the opinion of the authors that competitive behavior reflects the strength of the underlying motivational and aggressive forces which drive the individual to participate in this or other sports. If so, the development of valid tests of competitive behavior will be based upon the measurement of motivational and aggressive drives.

Reference

1. BOOTH, E. G. "Personality Traits of Athletes as Measured by the MMPI." *Research Quarterly* 29: 127-38; May 1958.

(Submitted 9/8/59)

COMMENTS

Comments on the article by A. G. Galarneaux and C. W. Thompson, "The Selection, Development, and Evaluation of Tobacco Smoking Concepts" in the May 1959 RESEARCH QUARTERLY.

The primary purpose of this study was to determine the validity and accuracy of tobacco smoking concepts. To do this, the authors obtained the opinions of 25 experts. Such methodology ignores the evidence of history and negates the need for experimentation. At the time of Galileo, the considered opinion of the experts was that the sun revolved about the earth; at the time of Columbus, that the earth was flat; at the time of Finlay, that yellow fever was transported by the miasmas of night air; and more recently, that the bumblebee is areodynamically incapable of flight. Opinion, regardless of how authoritative, remains opinion, and it is very doubtful that the validity and accuracy (assuming that there is a distinction) of a concept can be determined in this manner.

The measuring tool itself is highly questionable. Of the five items upon which the experts reached a consensus of opinion, three could have been negatively worded and elicited essentially the same percentage of "true" responses; e.g., "Smoke from tobacco may be annoying and unpleasant to other persons." It may also be pleasant to some. Sixteen of the 24 items in the psychological evaluation were of this nature.

Based on the responses of the experts, the authors have listed 19 "concepts" as "Very Important to General Education." An examination of the responses does not justify this list, for 10 of the "concepts" were considered true by less than 80 percent of the experts. A coefficient of concordance might have revealed much useful information, yet this was not done. In fact, no statistical analyses of the data were presented. Attention should be called to the fact that the coefficient of concordance indicates the ability of the experts to apply essentially the same standards. It does not indicate whether the concept is right or wrong.

In view of the above, there is no evidence to indicate that the validity and accuracy of smoking concepts have been determined or that the lists of concepts important to general education are other than what the authors believe to be the opinions of some experts.—*William R. Pierson, Research Center, College of Osteopathic Physicians and Surgeons, Los Angeles, California.*

(Submitted 6/19/59)

Research Abstracts

Prepared by the Research Abstracts Committee of the Research Council, D. B. VAN DALEN, Chairman

1. ADAMSON, G. T. "Circuit Training." *Ergonomics* 2: 183-86; February 1959.

Circuit training is a form of progressive resistance loading designed to improve general muscular and circulo-respiratory conditions. The "circuit" usually includes nine to twelve exercises performed consecutively. The main assumption underlying this approach is that general fitness is determined by muscular strength, muscular endurance, general endurance, and muscular power. Some results of training 20 university students for eight weeks are presented.—*David H. Clarke.*

2. ASMUSSEN, ERLING, and HEEBLL-NIELSEN, K. "Posture, Mobility and Strength of the Back in Boys, 7 to 16 Years Old." *Acta Orthopaedica Scandinavica* 28: 174-89; 1959.

It was the purpose of this investigation to determine whether there is a correlation between the form and function of the back in school children and to determine how these change during the school years. The concepts of "good" or "poor" posture are very subjective and to a high degree based on esthetical criteria rather than on mechanical or physiological principles. Measurements were taken by a special goniometer by which it was possible to measure the angles between a vertical frontal plane and the projection onto a sagittal plane of any line connecting two chosen points on the surface of the body. Muscular strength was measured by means of dynamometers during maximal isometric contractions.

Kyphosis seems to decrease slightly and lordosis to increase with increasing height. The inclination of the pelvis decreases with increasing height. Forward flexibility of the spine shows a tendency to increase with height. On an average, flexibility of the spine is larger in those with more pronounced lordosis and the strength of the back muscles is greater; for the abdominal muscles the tendency goes slightly in the opposite direction. The increase in muscular strength with height follows an exponential curve, due, probably, to the fact that muscular strength is proportional to the transverse section area of muscle, which must be expected to increase with height or any other linear measure.

The correlations suggest that backs with the larger lordosis are stronger and that the stronger backs exhibit more pronounced curves. There was no sign of better function in those with flat backs. This puts grave doubts on the value of the Harvard standard-types. One cannot avoid the thought that it has been fostered by people with prefixed ideas of how a good soldier ought to look. The assumption is that the more curved back is more functional.—*Philip J. Rasch.*

3. BALKE, BRUNO, and WARE, RAY W. "The Present Status of Physical Fitness in the Air Force." *School of Aviation Medicine, USAF report* 59-67.

Modern life has almost removed the necessity for greater physical effort. Conferences on physical fitness pose the question, "Fit for what — shuffling papers?" Since fitness is not defined, it is not measurable and standards cannot be defined. The purpose of this study was to obtain more information about the normal range of physical performance in man.

The test consisted of walking on a treadmill at a speed of 3.3 mph on a horizontal level. Each minute the angle was increased 1 percent. Attainment of a pulse rate of 180 beats per minute served as a cut-off point. Of the 500 Air Force personnel tested, 42 percent

were rated as being in "poor" physical condition, 49 percent as "fair," and 18 percent as "good." Those in poor condition would have little chance of surviving in emergency situations requiring a higher rate of energy expenditure.—*Philip J. Rasch.*

4. BONJER, F. H. "The Effects of Aptitude, Fitness, Physical Working Capacity, Skill and Motivation on the Amount and Quality of Work." *Ergonomics* 2: 254-61; May 1959.

Pulse rates and energy expenditures for dock workers and brick layers were collected to determine the most economical method of work and to detect long term effects on health. The economy of the work was judged by comparison of the effort expended and the resulting performance. The results were largely influenced by the personal capabilities for the performance of the particular task by each of the subjects. In general, difficulties are encountered if different groups of subjects are compared, each using their own work method, for the groups may differ too much in general working capacity. Also, if the same group applies different work methods, experience in using one method will be greater than with another.—*David H. Clarke.*

5. BROWN, J. R.; CROWDEN, G. P.; and TAYLOR, P. F. "Circulatory Responses to Change from Recumbent to Erect Posture as an Index of Heat Stress." *Ergonomics* 2: 262-73; May 1959.

Experiments are described in which Crampton Index values, for six subjects (2 female and 4 male), derived from measurements of blood pressure and pulse rate following change in posture, have been related to conditions of environmental heat and to the thermal sensations of resting and working subjects. Experimental evidence indicates that changes in the Crampton Index may be of value in defining individual reactions to increasing environmental heat. They were found to be closely associated with changes in sensations of heat and moisture, and marked decreases were associated with symptoms of thermal stress, such decreases being aggravated by muscular work.—*David H. Clarke.*

6. CATES, J. E., and MEADE, F. "Physical Training in Relation to the Energy Expenditure of Walking and to Factors Controlling Respiration during Exercise." *Ergonomics* 2: 195-206; February 1959.

In eleven men during a ten-week period of training, there was a decrease in energy expenditure and vertical work done in treadmill walking. This is attributed to increased economy of movement since the ratio of energy expended to work done remained constant. The reduction in exercise ventilation also decreased over the training period, suggesting improved oxygenation of the blood in the lungs. There was no concurrent change in pulmonary diffusing capacity or ventilation equivalent, and no experimental evidence was obtained to support the hypothesis that as a result of this training the body temperature rises less on exercise and that this contributes to the changes in exercise ventilation.—*David H. Clarke.*

7. CLARK, PHILIP J., and SPUHLER, J. N. "Differential Fertility in Relation to Bodily Dimensions." *Human Biology* 31: 121-37; May 1959.

From a random selection of the adult population in Ann Arbor, Michigan, this study indicates that for both males and females there is a tendency for individuals of above average fertility to be more stockily built than individuals of less than average fertility. It is unclear from the analyses whether a stocky build tends to result in above average fertility or whether the factors associated with above average fertility, such as marital status and socioeconomic level, tend to result in a stocky build.—*D. B. Van Dalen.*

8. CLARKE, DAVID H. "Progressive Resistance Exercise in Corrective Therapy." *Journal of the Association for Physical and Mental Rehabilitation* 13: 118-21; July-August 1959.

Recent research regarding static and dynamic exercise is reviewed, with particular reference to providing a physiological interpretation. In addition, some objective bases

for determining resistance load in progressive resistance exercises are summarized.—*David H. Clarke.*

9. Clarke, R. S. J., and Hellon, R. F. "Hyperaemia following Sustained and Rhythmic Exercise in the Human Forearm at Various Temperatures." *Journal of Physiology* 145: 447; March 12, 1959.

Cooling the forearm in an 18°C. water bath had the following effects on post exercise hyperaemia: a) reduced it after sustained contraction, b) failed to change it after rhythmic contractions at the rate of 30/min., and c) increased it after rhythmic contractions at the rate of 60/min.

These findings may have some applicability in the study of "warm-up." The authors attempt to explain the increased reactive hyperaemia after rhythmic contractions at the rate of 60/min. by implying that with the increase in viscosity of the forearm muscles on cooling, the total metabolism of the working muscles is increased. This increase provides additional metabolites, one or more of which may enhance the reactive hyperaemia.—*E. R. Buskirk.*

10. Davis, Morris C. "The Athlete and Chronic Illness: An Essay on Human Potential." *Medical Journal of Australia* I: 797-800; June 13, 1959.

In chronic ill-health the morbid process of destruction is slow, and amazing physiological adaptation becomes possible. The reserve capacity which every organ possesses may be called "human potential." Factors affecting the athlete's potential include: (1) vasomotor makeup of the individual—the neurocirculatory asthenia so frequently seen in athletes must not be mistaken for heart disease; (2) heat production—under humid conditions the temperature may increase to 108°F., with possible development of heat stroke; and (3) age—in some branches of athletics maximum efficiency may not be reached until the early thirties.

In the examination of athletes we should particularly look for the following conditions: (1) chronic morbid change in the cardio-vascular system, particularly enlargement, valvular lesions, and hypertension; (2) chronic renal disease, particularly albuminuria, polycystic kidney, and chronic pyelonephritis; (3) chronic sepsis; (4) chronic nutritional deficiency; (5) chronic lung disease; (6) endocrine changes; (7) diabetes; (8) anemia.

Excessive rest may more rapidly cause wasting than activity. The judicious maintenance of activity in the presence of disease states is of great importance when such a state is found in the athlete.—*Philip J. Rasch.*

11. DeLanne, R.; Barnes, J. R.; and Brouha, L. "Changes in Osmotic Pressure and Ionic Concentrations of Plasma during Muscular Work and Recovery." *Journal of Applied Physiology* 14: 804; September 1959.

Ion concentrations, freezing point depression, and conductivity of plasma were measured in both men and women before, during, and after they pedaled a bicycle ergometer in various environments. The work rates and durations for the men and women were respectively: (a) men—30 minutes at 540 kgm/min. followed by 4 mintes at 900 kgm/min.; (b) women—30 minutes at 360 kgm/min. followed by 4 minutes at 720 kgm/min.

Variable increases in ionic concentrations with exercise were observed. Total osmolality (freezing point depression) also increased and paralleled the increase in the osmolal sum of the separate ions. Although it has been implied by others that plasma conductivity can be used to calculate total cations, plasma conductivity decreased and could not be related to either changes in ionic concentration (other than bicarbonate) or freezing point depression. Heat, the common denominator, in the simulated tropical and desert environment had a variable effect on the concentration of the individual ions. For example, both plasma K^+ and lactate$^-$ were reduced during recovery from exercise as a result of exposure to heat. The changes in the measured variables were about the same for men and women when the difference in workload was considered.—*E. R. Buskirk.*

12. DILL, D. B. "Fatigue and Physical Fitness." *Journal of the Association for Physical and Mental Rehabilitation* 13: 109-17; July-August 1959.

Some of the manifestations of fatigue are described, particularly with respect to exhausting work of short and long duration. Some physiological considerations concerning the role of lactic acid and the alactacid and lactacid debts are summarized, as are other phases of anaerobic and aerobic work. Fatigue involves depletion of carbohydrate, and may also involve breakdown because of high body temperature. Fitness depends on efficiency and also on a high capacity of the respiratory-circulatory systems for supplying oxygen to tissues. Reference is made to several unpublished wartime studies of physical fitness.—*David H. Clarke.*

13. ECCLES, J. C., and WILEY, A. W. "Factors Controlling the Liberation of Acetylcholine at the Neuromuscular Junction." *American Journal of Physical Medicine* 38: 96-103; June 1959.

A number of studies have shown that the neuromuscular junction is the site of spontaneous subthreshold potentials resulting from the random release of quanta of actetylcholine from the motor nerve terminals. A nerve impulse produces the coordinated discharge which makes up the e.p.p. by a transient acceleration of these resting discharges. This is affected by a depolarization of the membrane, which releases the quanta from their containing vesicles.—*Philip J. Rasch.*

14. FLOOD, FRANK B. "Albuminuria and Hematuria in Boxers." *Journal of the American Medical Association* 171: 1678; November 1959.

Forty-nine paired specimens of urine, one voided before and one immediately after a bout, were obtained from 35 amateur boxers and examined for blood with the benzedrine test and screened for albumin with Uristix strips. Trace readings for albumin were considered negative and positive results checked by Exton's method using sulfosalicylic acid. After five subjects showing prebout albuminuria were excluded, 15 percent showed postbout albuminuria. Postbout hematuria was present in 28 percent of total subjects.

Flood's criterion for hematuria was 12 erythrocytes per high power field as compared with six per field used by other previous investigators. He states incidence of both hematuria and albuminuria would have been higher had criteria been less strict. Kleinman in 1958 reported an incidence of hematuria in professional boxers of 27 percent, while Amelar and Soloman in 1954 reported as high as 90 percent during rounds 7-12. Amelar and Solomon also reported a 68 percent incidence of postbout albuminuria.

Question remains unsolved as to whether hematuria and albuminuria can be caused solely by strenuous exercise.—*Lora M. Ewing.*

15. GERHARD, D. J. "The Judgment of Velocity and Prediction of Motion." *Ergonomics* 2: 287-304; May 1959.

Varying the amount of time 12 subjects were able to view the progress of a light they were to intercept on a screen indicated their ability to deal with this using a comparatively simple response technique. However, further data were gathered using a situation in which the subjects had to predict when the moving light which had disappeared had reached a specified point. A systematic relationship exists between the variability of the subject's performance and the time the light has been invisible. The relationship closely approximates $V^2 = Kt^2$ where V is the variability of the subject, t the time the light was obscured, and K a constant.—*David H. Clarke.*

16. GOLDSTEIN, ALVIN G. "Linear Acceleration and Apparent Distance." *Perceptual and Motor Skills* 3: 267-69; September 1959.

Forward and backward acceleration from 0 to 60 mph of 33 observers (Os) was accomplished in a fluid drive automatic transmission automobile. Acceleration from 0 to 60 mph require 10 to 11 seconds. Os reported changes in perception of an illuminated ring. The ring was at a fixed distance (3 feet) from O during the entire experiment.

Of all responses, 52 percent concerned change in apparent distance, 14 percent concerned size changes, and seven percent both distance and size changes. There was a reliable relation between perceiving the ring as approaching during the forward acceleration and as receding during the backward acceleration. Deceleration from a forward motion resulted in more perceptions of stimulus approach, and the deceleration from backward motion led to opposite perceptions.—*D. B. Van Dalen.*

17. Govatos, Louis A. "Relationships and Age Differences in Growth Measures and Motor Skills." *Child Development* 30: 333-40; September 1959.

Data was collected from 101 elementary school children. When the individual aspects of growth and organismic age were correlated with each motor skill, the relationships were found to be positive and significant for both sexes. The jump and reach and the 25-yard dash possessed higher correlations with some growth measures for girls than for boys. The above do not, however, hold true for motor skills. When chronological age was held constant, the relationships between growth measures and organismic age and motor skills were low and in some cases negative. Reading and mental growth measures approach zero correlations with motor skills.—*D. B. Van Dalen.*

18. Hemingway, Albert. "Physiological Bases of Training." *Ergonomics* 2: 133-42; February 1959.

The aim of athletic training is to increase skill, endurance, and strength. In general, it is necessary to develop the individual's resources until he can undertake tasks originally beyond his capabilities. Attention to such factors as length of stride, speed of movements, load, and posture can lead to more economical use of the body, as can training by repetition, or the use of auxiliary movements. Strength and endurance are developed only by exercises at or close to the limit of performance. Recent evidence shows that the difference between the trained and untrained man is that the former is able to increase his heart output and transport oxygen to his muscles at a higher rate than the latter.—*David H. Clarke.*

19. Hohman, L. B., and Freedheim, D. K. "A Study of I.Q. Retest Evaluations on Three Hundred Seventy Cerebral Palsied Children." *American Journal of Physical Medicine* 38: 180-87; 1959.

Three hundred and seventy palsied children were tested for I.Q. evaluations with test periods ranging from six months to five years. One hundred and twenty-two were retested between six months and one year. Seventy-seven were retested between six months and one year. Seventy-seven were retested between thirteen to eighteen months or longer. One hundred and seventy-one were retested at nineteen months or longer.

Results showed that the levels of I.Q. remained the same. The smallest percent change occurred in the ninety to fifty below I.Q. group. The largest percent change occurred in the fifty to seventy group. There were fewer shifts in I.Q. with older children (six years and older).—*C. Etta Walters.*

20. Huckabee, W. E. "Relationship of Pyruvate and Lactate during Anaerobic Metabolism. IV. Local Tissue Components of Total Body O_2-Debt." *American Journal of Physiology* 196: 253; February 1959.

This paper is a continuation of an extended investigation of the relationship between anaerobic metabolism and the rate of accumulation of "excess lactate" in body fluids. In anesthetized dogs breathing 10 percent O_2, "excess lactate" was highly variable with time in the various regions of the body studied. It was felt that excess lactate was distributed in a given area in proportion to the cardiac output in that area. Although "excess lactate" changes in local tissues did not appear to be related to O_2-debt, a summation of regional "excess lactate" exchanges gave a satisfactory approximation of O_2-debt. Thus, measurements of oxygen debt do not indicate the adequacy of oxygen supply in a specific region of the body nor do blood samples drawn from local areas necessarily present a "true" picture of total body "excess lactate."—*E. R. Buskirk.*

21. JOHNSON, THOMAS, F. and others. "The Influence of Exercise on Serum Cholesterol, Phospholipids and Electrophoretic Serum Protein Patterns in College Swimmers." *Federation Proceedings* 18: 77; March 1959.

Physical activity by man on a high fat diet tends to inhibit the elevation of serum cholesterol. Eleven swimmers covered one and one-half miles per day, in addition of 40 percent or more of dietary fat. After several months no significant changes in serum cholesterol, phospholipids, or electrophoretic serum protein patterns were noted. This seems consistent with the premise that physical activity is effective in stabilizing serum cholesterol.—*Philip J. Rasch.*

22. JOKL, ERNEST. "Physical Fitness and Susceptibility to Infections." *Journal of the Association for Physical and Mental Rehabilitation* 13: 141-44; September-October 1959.

Various studies on diseases and infections in clinical physiology of exercise indicate that athletes have no immunological protection beyond that of the population at large. Nor is there a consistent relationship between humoral and general immunity and physical fitness. The problem of the effect of exercise upon susceptibility towards infections must be examined for each diagnostic or epidemiological condition. In a study conducted during an influenza epidemic, the percentage incidence of children afflicted by the disease was the same for a sample of trained children and for untrained controls.—*David H. Clarke.*

23. KARVONEN, M. J. "Problems of Training of the Cardiovascular System." *Ergonomics* 2: 207-15; February 1959.

The cardiovascular system may be considered trained when a large cardiac output is developed, with the aid of a high maximum oxygen uptake. This may effect several structural, chemical, and functional changes, some of these changes occurring only when training takes place at high pulse rate levels. Training increases the performance capacity of strenuous exercise, and may reduce the effort needed to perform submaximal work. Also, training is not known to produce detrimental effects on health, for the longevity of trained athletes is equal to or even longer than that of other comparable groups. The serum cholesterol level may be lower in trained subjects than in the general population.—*David H. Clarke.*

24. LANCET. "Boxing." (Editorial) *Lancet* 7084: 1185-86; June 6, 1959.

Early this year a former welterweight boxing champion was admitted to a mental hospital. In May a young amateur boxer died after being knocked out and another former welterweight champion was operated upon for intracranial haemorrhage. Most of the hazards of boxing are cerebral. Death is usually from gross injury to the brain or its vessels. Sixty-four boxers, including 22 amateurs, were killed in 4 years. The reality of the punch-drunk syndrome has been established beyond question. The medical case against boxing is so strong that doctors have a clear duty to figth for its total abolition.—*Philip J. Rasch.*

25. LIND, A. R. "Muscle Fatigue and Recovery from Fatigue Induced by Sustained Contractions." *Journal of Physiology* 127: 162; June 23, 1959.

Repeated sustained contractions (1/5 maximum tension) were performed while the forearm was immersed in water at 18°C. or at 34°C. The duration of contraction for a given interval between contractions (3, 7, 20 or 40 min.) was always greater in water at 18°C. than at 34°C. Representative muscle temperatures are presented. Recovery of the ability to maintain submaximal contractions was exponential. Over 50 percent of the recovery occurred in the first 10 minutes while only 25 percent occurred in the subsequent 30 minutes after contraction. Water temperature did not appreciably affect the rate of recovery when the interval between contractions was more than seven minutes. The rate of recovery was more rapid in 34°C. than in 18°C. water when the interval

between contractions was 7 minutes or less. A tentative explanation for a two-component recovery curve is presented.—*E. R. Buskirk.*

26. Mangan, G. L.; Quartermain, D.; and Vaughan, G. "Relationship between Taylor MAS Scores and Group Conformity." *Perceptual and Motor Skills* 3: 207-09; September 1959.

Students who scored highest and lowest on the shortened 28-item Taylor MAS were subjected to conformity pressure induced by dummy Ss. Diferences in total judgments of which of the two groups of dots contained the larger number were found not to be significant. However, percentages of yielding responses were found to vary significantly with Ss' position in the response sequence. High anxiety Ss yielded less than low anxiety Ss as group pressure increased.—*D. B. Van Dalen.*

27. Mellerowicz, H., and Lerche, K. "Ergometrische Untersuchungen zur Beurteilung der Leistungsfähigkeit Jugendlicher." ("The Estimation of the Work Capacity in Youth by Ergometric Methods") *Arbeitsphysiologie* 17: 459-68; July 1959.

Four groups of male high school students (N = 40 per group, aged 12-19) performed on a hand and arm ergometer for 3 and 6 minutes during which they tried to reach a maximal total work-output. The heart rate during and after the exercise was obtained. While the older groups performed more work during the task time, the difference was not apparent when comparisons were made on the basis of output per kg of body weight. Comparison with an older group of untrained men (N = 100, aged 20-30) also failed to show a difference when compared on this basis. The differences in heart rate at different stages of the tasks were also negligible between age groups.—*J. Royce.*

28. Milic-Emili, G. "Heart-rate and Ventilation during Recovery from Heavy Exercise in Trained and Untrained Individuals." *Arbeitsphysiologie* 17: 455-58; July 1959.

Heart-rate and ventilation curves during recovery from an exhaustive walk on a treadmill (at 5.5 km/hr and 20% slope), were found to be composed of a rapid and of a slow component, both exponential in character. The half-time constants of the rapid components were lower in the trained (N = 10) than in the untrained (N = 10), male subjects.—*J. Royce.*

29. Müller, E. D. "Training Muscle Strength." *Ergonomics* 2: 216-22; February 1959.

The rate of increase of muscular strength brought about by various training procedures is reviewed. The stimulus for increasing strength is not fatigue, but an increase in the tension over that previously exerted. When this force exceeds one-third of maximum strength, the greatest speed of increase in strength is reached with one single, short duration static contraction per day. With a single contraction each week, the rate of increase is diminished by one-third. Inactivity decreases strength 30 percent in a week, although one isometric contraction per day, at one-fifth of maximal strength, is sufficient to maintain normal strength. Sex and age differences are discussed and some physiological implications made.—*David H. Clarke.*

30. Nachmansohn, David. "Role of Acetylcholine in Axonal Conduction and Neuromuscular Transmission." *American Journal Physical Medicine* 38: 190-206; 1959.

The electrical and chemical theories in nerve conduction are discussed and the role of acetylcholine in neuromuscular transmission is elucidated.—*C. Etta Walters.*

31. Pierson, William R., and Rasch, Philip J. "Determination of a Representative Score for Simple Reaction and Movement Time." *Perceptual and Motor Skills* 2: 107-10; June 1959.

The reaction time and movement time of 260 male Ss between the ages of 8 and 30 were measured on 30 trials by a fractioning process employing two chronoscopes. For the population used, the authors proposed that (1) the mean of Trials 16 to 20 appeared to be the most practical figure to use as a score representative of the S's speed of simple

reaction and of movement which was defined as the extending of S's arm through a light beam placed 11 inches in front of him, and (2) age was not a factor in the trial-to-trial improvement of reaction or movement time scores.—*D. B. Van Dalen.*

32. Rarick, G. L., and Larsen, G. L. "The Effect of Variations in the Intensity and Frequency of Isometric Muscular Effort on the Development of Static Muscular Strength in Pre-Pubescent Males." *Arbeitsphysiologie* 18: 13-21; September 1959.

Strength-equated groups (N = 9 per group, mean age 12.5 years) of prepubescent males were compared as to the strength gain resulting from two different static exercise programs. One program consisted of one maximal isometric contraction (6 sec.) a day, while the other consisted of four to six daily contractions at 80 percent of the maximal strength. While both groups in four weeks gained significantly over the control group, the difference between the two groups remained insignificant. Four weeks discontinuing the program, the strength retention was approximately the same for both experimental groups.—*J. Royce.*

33. Rice, Lester, and Fishbein, William. "Exercise Table for Muscle Strength." *Inductrial Medicine and Surgery* 28: 278-79; June 1959.

A group of 52 women was given passive exercise for ten weeks on a table which alternately stretched given muscle groups and then permitted them to relax. The average strength of the muscles increased, the increases varying from 2.9 percent for the muscles of the neck and upper shoulders to 16.9 percent for the posterior muscles of the triceps. There was no significant change in the strength of a control group of 26 women.—*Philip J. Rasch.*

34. Schoonover, Sarah M. "The Relationship of Intelligence and Achievement to Birth Order, Sex of Sibling, and Age Interval." *Journal of Educational Psychology* 50: 143-46; August 1959.

An analysis was made of sibling performance on intelligence and achievement tests utilizing longitudinal data from the records obtained at the University of Michigan. No significant differences were found between older and younger siblings in intelligence or achievement as measured by deviation from the norms for chronological age. Sibs, irrespective of sex, with brothers consistently had higher mental and achievement ages than sibs with sisters. The relationship between interval between births and the average difference in intelligence and achievement for sibling pairs was insignificant.—*D. B. Van Dalen.*

35. Sloan, A. W., and Keen, E. N. "Physical Fitness of Oarsmen and Rugby Players before and after Training." *Journal of Applied Physiology* 14: 635-36; July, 1959.

The effect of physical training on the resting pulse and Harvard Step Test scores were studied in oarsmen, rugby players, and controls not undergoing any systematic athletic training. Subjects were tested at the beginning of the academic year, and the tests were repeated two to four months later. At the beginning of the investigation there was nc significant difference in resting pulse rates between the three groups, but the rowing and rugby groups had significantly higher fitness indices than the control group. There was no significant difference in the fitness indices of the two groups of athletes. At the end of the training period the resting pulse rate was significantly slower in the athletic groups than in the controls. The rise in physical fitness indices in the athletes was highly significant, whereas no significant change occurred in the controls. There was no significant difference in this respect between oarsmen and rugby players. In the athletic groups there was a significant correlation between low resting pulse rate and high fitness index, but in the controls there was no significant correlation between resting pulse rate and fitness index. The fitness index appears less subject to variation as a result of extraneous factors and more closely related to the capacity for strenuous exertion than does a low resting pulse.—*Philip J. Rasch.*

36. SLOCUM, DONALD B. "The Mechanics of Common Football Injuries." *Journal of the American Medical Association* 170: 1640–46; August 1959.

A comprehensive analysis of the mechanics of common football injuries is presented. The manner in which many injuries may be incurred and the injuries most likely to occur in a given situation are discussed. The author believes if the mechanics of the injury are understood, adequate diagnosis, prevention, and treatment can be undertaken. Common injuries to the upper extremity, pelvis, lower extremity, and the head and spine are described as well as the mechanics of their occurrence. The knee as a lethal weapon in football is also presented.—*Carl S. Blyth.*

37. SMITH, GENE, and BEECHER, HENRY. "Amphetamine Sulfate and Athletic Performance." *Journal of the American Medical Association* 170: 542; May 1959.

Study consisted of two parts. During the first part, 7 mg. of amphetamine per 70 kg. of body weight were given 1 to 2 and ½ hours before the test. During the second part, 14 mg. of drug were given 2 to 3 hours before the test. During the first part 11 out of 14 swimmers and 2 out of 6 runners improved their times with amphetamine. During the second part, 18 swimmers, 26 runners, and 13 weight throwers were used in 781 tests. The ergogenic effect of amphetamine was statistically significant for all throwers performed better with amphetamine than with a placebo.—*P. V. Karpovich.*

38. SPERRY, R. W. "The Growth of Nerve Circuits." *Scientific American* 201: 68; November 1959.

Evidence is presented which has (1) resulted in the last 15 years in a reversal of scientific and medical opinion regarding learning and (2) provided an explanation of built-in behavior mechanisms from the simplest reflex to the most complicated patterns of inherited behavior. Connections necessary for normal coordinations arise in embryonic development according to a biochemically determined plan that precisely connects the various nerve endings in the body to their corresponding points in the main centers of the brain and spinal cord. Higher centers in the brain are capable of extensive learning but lower centers in the brain stem are quite implastic.—*Ruth B. Glassow.*

39. STIER, F. "Die Geschwindigkeit von Armbewegungen." ("The Speed of Arm Movements") *Arbeitsphysiologie* 18: 82-100; September 1959.

Eight different types of swinging arm movements were made by three subjects. Within each type of movement, the frequency and amplitude were varied. The inertia of the arm was changed systematically by adding weights. The optimal combinations of the above variables were determined in terms of the energy cost of repeated movements. The author theorizes that the optimal speed (in terms of energy cost) of contraction of the muscles is reached when the muscle shortens under a constant optimal muscle tension of .4 to 1.0 kg per square centimeter of physiological cross section.—*J. Royce.*

40. STOBOY, H.; NÜSSGEN, W.; and FRIEDEBOLD, G. "Das Verhalten der Motorischen Einheiten unter den Bedingungen eines Isometrischen Trainings." ("The Action of the Motor Unit under the Influence of Isometric Strength Training") *Arbeitsphysiologie* 17: 391-99; March 1959.

Nine female subjects (aged 19-23) contracted the quadriceps femoris maximally against a spring for ten sec. per day, for five days per week. On the sixth day, the the maximal isometric strength was measured, as well as the time a constant weight could be held. This weight was a certain percentage of the recorded strength. The progress from week to week was determined for eight weeks. Moreover, the electrical activity of the muscle was recorded during the holding of the constant weight. The results show that the total electrical spike frequency decreases exponentially during the seven-week period following an initial sharp increase recorded at the end of the first week When the spike frequency was measured at the beginning, middle, or end of the "holding test," it became clear that the electrical activity for these times decreased during the last seven weeks of exercise, except for the fact that electrical activity

increased again after the sixth week of training for the "end frequency." The author concludes that the overall decrease of electrical activity during progressive strength training is due to a desynchronization of the impulses from the anterior horn cells.—*J. Royce.*

41. WITKIN, HERMAN A. "The Perception of the Upright." *Scientific American* 200: 50; February 1959.

Beginning with studies on perception of the vertical which could be determined only by the surroundings or by the body position, the investigators conclude that people have well-established, preferred ways of perceiving, attributable to variations in psychological organization. Women were found to be more field dependent (surroundings) than men; average field dependent scores decrease with age, particularly marked in ages eight to thirteen, though each individual tends to remain relatively stable within the group. Field dependents score high on I.Q. items concerned with vocabulary, information, and comprehension; field independents score high on items emphasizing analytical competence and function with greater independence in a variety of situations. A high relationship was found with mothers' characteristics, those who restricted the child's activity, stressed conformity and whose physical care seemed inappropriate to the child's age had children who were field dependent. The linkage between perception and personality suggests a useful approach to experimental study of personality.—*Ruth B. Glassow.*

42. WEDLICK, LEIGH T. "Sports Injuries." *Medical Journal of Australia* I: 800-01; June 13, 1959.

The treatment of sports isjuries is particularly difficult because of the athlete's tendency to return to competition before recovery is complete. Prevention of sports injuries includes (1) medical examination of the athlete; (2) conditioning; (3) teaching by the coach of correct techniques; (4) "warming up"; and (5) correct apparatus and safety precautions.

Prompt medical examination of injuries is essential. Musculo-tendinous injuries tend to be neglected at the start or mistreated by a "rubber" and may become more troublesome than a fracture or dislocation. A blow to the thigh, with the development of effusion of blood into the muscles, should be treated for the first 24-48 hours with rest and perhaps a pressure bandage. This should be followed by heat and carefully graduated active movements to make sure that stiffness does not develop in the joints. It is important to give graduated resistance exercises to obtain full muscle power. If active movements are not carried out, adhesions which limit the range of movement and cause recurrent pain may develop. Use of ultrasonic irradiation and injections of novocain and hydrocortisone may prove helpful.

Full activity should not be resumed until recovery is complete, evidenced by freedom from pain, full range of movement, and full muscle power. If activity is resumed earlier, the injury tends to become chronic. In some cases the period away from sport may be prolonged, notably in the case of javelin elbow. In knee injuries it is vitally important to ensure full power in the quadriceps muscles.—*Philip J. Rasch.*

43. ZELLWEGER, HANS, and BELL, WILLIAM E. "Congenital Muscular Hypertrophy." *Neurology* 9: 160-66; March 1959.

The first report of congenital muscular hypertrophy in infants was made by Bruck in 1889. He described a ten-months-old girl as having the appearance of a wrestler due to the hypertrophied muscular system. Since that time a number of other cases have been reported, including three in this paper. A review of the literature indicates that congenital muscular hypertrophy in infancy is not a disease entity. Evidently several different categories exist. It may be associated with brain disease, Thomsen's disease, or muscular glycogenosis, or may be a benign idiopathic condition.—*Philip J. Rasch.*

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